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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **700** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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J. WALDO SMITH,

President New England Water Works Association,

1913.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXVII. March, 1913. No. 1.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE LOWELL WATER WORKS AND SOME RECENT IMPROVEMENTS.

BY ROBERT J. THOMAS, SUPERINTENDENT OF WATER WORKS, LOWELL, MASS.

[*Read January 8, 1913.*]

Some improvements recently made in the water works of the city of Lowell, including an extension of the driven well system and the construction of a new pumping station and distributing reservoir, are to serve as an excuse for the presentation of this paper for your consideration.

It is proposed, however, as a preliminary to the description of these improvements, to review the development of the water system to date, in the belief that the experience of a city of more than 100 000 people in obtaining a supply from an underground source may be of general interest.

The installation of water works was discussed as early as 1838, but nothing was done until 1870, when, after a report by Mr. J. Herbert Shedd, and another by Mr. Joseph P. Davis, construction was begun, following the recommendations of the latter engineer, who advised filtration of the Merrimac River water, with preliminary sedimentation. The water was to be taken from the north side of the river at a point a short distance above the Pawtucket dam, and carried through an oval brick conduit with a capacity of 9 000 000 gal. per day, to settling basins of twenty-four-hour capacity and filters located near the outlet of Beaver Brook. From the filters the water was to flow through a second brick

conduit 4 ft. 6 in. in diameter, passing under Beaver Brook in a cast-iron inverted siphon, and terminating in a clear water well 100 ft. square and 10 ft. deep, at a pumping station in Centralville. From the pumping station the water was to be pumped to an open distributing reservoir of 30 000 000 gal. capacity, with high water at elevation 181.5, located on Beacon Hill. The datum of all elevations herein referred to is 47.28 ft. above mean low water at Boston.

Work was begun in July, 1870, but for some reason the scheme of the engineer was materially changed, the settling basins and filter beds being abandoned and a filter gallery 8 ft. square in section and with its bottom 8 ft. below the crest of the Pawtucket dam was substituted, these changes being, in the first place, the result of a belief in the minds of the city authorities that the river water was safe without filtration, and also because investigation apparently indicated the possibility of obtaining a sufficient supply of ground water from the gravel deposits along the river bank.

As constructed, the work consisted of the filter gallery 1 300 ft. long, about 100 ft. from the shore line of the river, a brick conduit 4 ft. 3 in. in diameter, 4 183 ft. long, and 6 656 ft. of 30-in. pipe ending in the pump well at the Centralville station. A 30-in. pipe 220 ft. long, controlled by gate valve, was also laid from the filter gallery to the river, with the idea that, should the gallery prove insufficient at low stages, the deficiency might be made up by direct draft from the river.

The distributing reservoir was uncovered and was constructed from the material excavated, with earth embankments 15 ft. wide on top and $1\frac{1}{2}:1$ slopes on the inside and $2:1$ slopes on the outside. The inside slopes were lined with clay puddle 2.5 ft. thick and paved with granite blocks 15 in. thick, underlaid with 10 in. of broken stone. The bottom was covered by one foot of puddle, but not paved. In 1886, when the water was drawn off for the purpose of cleaning, the interior slope started to slide, necessitating reinforcement, and as a result the reservoir has not since been emptied. The force main, which leads directly from the pumps without connection with the distribution system, extends to the back of the reservoir, insuring circulation and a storage period which has averaged about five days.

It had been estimated that the filter gallery would yield 2 500 000 gal. per day, but in 1875 only 900 000 gal. per day could be obtained, and as the daily consumption had reached 1 220 000 gal., the balance was taken direct from the river. To prevent the use of this raw water, a sand filter bed, well underdrained and composed of 36 in. of gravel and 48 in. of sand, having an area of 11 400 sq. ft., and the surface of the sand one foot below the crest of the Pawtucket dam, was constructed in 1876 on the bank of the river. Water was admitted from the river through a 12-in. pipe, and the underdrains were connected with the filter gallery by a 30-in. pipe.

With the growth of the city in the higher districts, it became necessary to develop greater pressure in certain areas, and accordingly the distribution system was divided, and in 1881 a high service reservoir with flow line at elevation 253.5 was constructed. This reservoir is uncovered, 150 ft. by 130 ft. in horizontal dimensions, and 17 ft. deep, and has a capacity of 1 300 000 gal. The embankments of earth obtained from the excavation are 17 ft. wide on top, with slopes of $1\frac{1}{2}:1$ on the inside and $2:1$ on the outside. A lining of puddle 2 ft. thick on the slopes and one foot thick on the bottom was provided, and the slopes are paved with granite blocks 12 to 15 in. thick, underlaid with 10 in. of broken stone. To supply this reservoir, an independent pump and 12-in. force main were provided.

The filter bed, because of rapid silting up of the surface, did not prove as effective in meeting the requirements of the city as anticipated, and after 1879, when the consumption had reached 2 000 000 gal. per day, an amount of raw water, which gradually increased from year to year, was drawn from the river. During this time, typhoid became prevalent and in 1890–91 serious epidemics in Lowell and Lawrence forced an effort to obtain a better supply. Search for ground water was made by driving test wells along the bank of the river above the filter gallery, and near Beaver Brook, but without success. Better results were, however, obtained in the valley of River Meadow Brook, south of the city, and here water in large quantity, and of apparently good quality, was found. In 1893 a contract was accordingly made with the Cook Well Company, whereby this company was to drive wells

and lay the suction pipes necessary to furnish a supply of 5 000 000 gal. per day for the sum of $24 250. Forty-five 6-in. wells provided with Cook strainers of variable length, depending on the depth of water-bearing stratum, were sunk by sand bucket to depths varying from 47 to 67 ft. All joints were flanged, and each well was separately gated from the suction main. These wells at first yielded 7 000 000 gal. per day, but the supply quickly fell to 2 000 000 gal. per day. As a result, fifteen 4-in. wells were driven and the supply increased to 3 000 000 gal., but after sixteen months' test, the contractor concluded that the original guarantee of 5 000 000 gal. daily could not be fulfilled and abandoned his contract. In 1893, 28 per cent. of the water used by the city was furnished by the Cook wells. Believing, however, that a greater supply could be obtained from the valley of River Meadow Brook, the city in 1894 entered into a contract with the Hydraulic Construction Company of New York to provide an additional plant, located so as not to interfere with the Cook wells, which should deliver not less than 2 000 000 gal. daily, for the sum of $19 749 per million gallons, including wells, pipe system, pumping machinery, and accessory apparatus. It was stipulated that not more than 3 000 000 gal. daily should be paid for in any event.

The contractor drove one hundred and twenty 2-in. wells and obtained, without apparently reaching the limit of the supply, 3 000 000 gal. per day. These wells, sunk by wash pipe, and averaging about 45 ft. deep, were located about a mile upstream from the Cook wells, two thirds of the total number being driven in two lines 12 ft. apart, parallel to the old canal and 200 ft. southwest of it, the wells being 25 ft. apart in the lines. The remaining wells are located in two similar parallel lines, extending at right angles from the center of the other lines. Subsequently additional wells were added to the Cook system, making the total in this plant fifty 6-in. wells and forty of smaller sizes, but the total yield of all wells in the valley of River Meadow Brook proved somewhat less than 5 000 000 gal., and as the daily consumption in 1895 had risen to about 7 000 000 gal. it was still necessary to draw water from the river, 34 per cent. of the total supply being so obtained in this year.

It is interesting to note that the watershed of River Meadow Brook has an area of about ten square miles, and that some sections of the valley are covered by deposits of peat and vegetable muck.

In 1895 the State Board of Health concluded that not more than one half of the water required could be obtained from this source during the dry season, stating also that the supply had grown harder and the color, ammonias, and iron had increased with continued use, and advising that the city proceed to obtain a supply of pure water from some adequate source, or filter the Merrimac River.

In 1895, after an investigation of the Groton ponds and Salmon Brook had proved the infeasibility of these sources, the city authorities decided on a further development of an underground supply, — locating the wells between the Pawtucket Boulevard and the Merrimac River, about two miles above the dam in land which had already been given to the city for park purposes.

In July, 1895, a contract was made with B. F. Smith & Co., whereby this company was to deliver 2 000 000 gal. per day for the sum of $13 461.70 per million gallons, demonstrated to be available by the contractor for one year, this price to cover wells and piping, but the contractor to provide the pumping plant, which the city reserved the right to purchase at 75 per cent. of its cost. A first line of 60 wells was driven 34 ft. from the south side of the boulevard, and parallel thereto, yielding 800 000 gal. per day. Another line of 66 wells was then driven parallel to the first, and 280 ft. nearer the river, averaging 25 gal. per minute per well, but so much ammonia and iron developed in the water that this line was pulled up and abandoned. A line of 22 wells running north and south, and another line of 122 wells parallel to the river, but 110 ft. further away from the river than the abandoned line, were then driven, — the final outcome being 169 effective wells, which yielded about 4 000 000 gal. daily. The city purchased the plant from the contractor for $45 000, including wells and pumping equipment.

The wells just described vary in depth from 27 to 40 ft. and are located at a distance of 150 to 350 ft. from the bank of the river. The suction main ranges from 10 to 24 in. in diameter, and ends

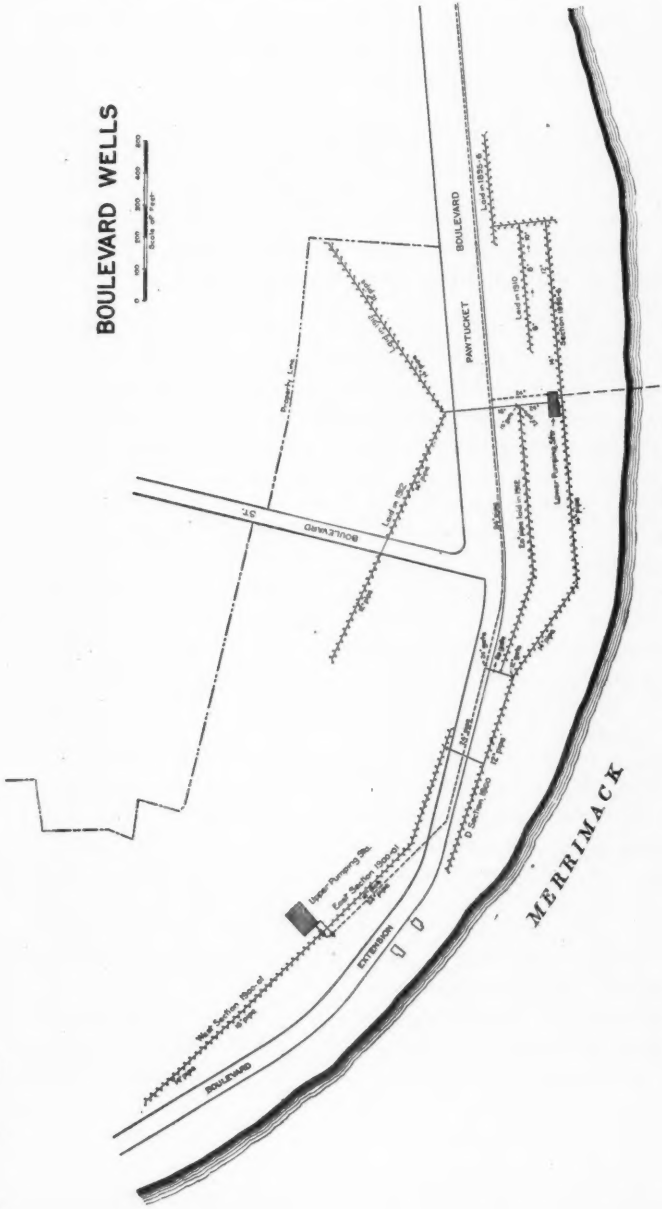

BOULEVARD WELLS
Scale of Feet
PAWTUCKET BOULEVARD
Power's Line
BOULEVARD ST.
Upper Pumping Sta.
East Section 150 in. d
West Section 150 in. d
EXTENSION
BOULEVARD
MERRIMACK RIVER

FIG. 1.

in a receiver 6 ft. in diameter and 11 ft. long, from which air is withdrawn by vacuum pumps through a riser pipe connected to the top of the receiver.

A low pressure 24-in. cast-iron force main, 9 600 ft. long, leads from the pumps to the old filter gallery, and thence flows to the Centralville station, where it is pumped into the distributing reservoir.

After February, 1896, the Boulevard and River Meadow wells furnished a supply sufficient in quantity for the needs of the city without resort to the river, but soon the quality of the latter supply became a live issue. In 1897 complaints of tastes and odors, chargeable to the exposure of the ground water to light in the open reservoirs, were frequent, and the advisability of a covered standpipe was considered, but nothing was done.

After an investigation of the action of water upon lead, made during the preceding year, the State Board of Health in 1899 called the attention of the city authorities to the effect of the ground water — particularly that from the valley of River Meadow Brook — on lead service pipes, and to the danger existing from continuing to supply consumers with this water, impregnated with an accumulative poison. The corrosive action was attributed to the excessive carbonic acid in the Cook well water, which was found to be greater in amount than in any other supply in the state. The lead in this water during the hours of ordinary use was reported to average .41 parts per 100 000, or eight times the amount generally regarded as the danger limit. The carbonic acid in the Cook well water averaged about 3.95 parts per 100 000; the dissolved oxygen, 10.2 per cent. of saturation; while the corresponding figures for the water from the Boulevard wells were 1.84 per 100 000 and 15.8 per cent. Many severe cases of lead poisoning were reported, and the State Board of Health recommended either the replacement of all lead services or the abandonment of the River Meadow Brook wells and the extension of the Boulevard system.

Accordingly, 52 additional wells were driven in 1900, and connected to the Lower Boulevard pumping station, while in 1901 125 wells were added and a new station, known as the Upper Boulevard station. was constructed. This latter plant is about

1 900 ft. northwesterly of the lower station, and is connected therewith by a 24-in. main, which can be used either as a force main for the upper plant or a suction pipe from the upper wells to the lower station.

During 1902 and 1903, no water was drawn from the Cook wells, but the decrease in the supply obtainable from the Boulevard system made it necessary to use this water in amounts varying from 3.2 per cent. of the total consumption in 1904 to 19.4 per cent. of the total in 1911.

Coincident with the reduction in capacity of the Boulevard system, a gradual deterioration in quality, indicated by increasing ammonias and iron, with the attendant organism Crenothrix, occurred, giving rise to many complaints, and evident physically by the increased color and turbidity of the water.

In 1911 this reduction in capacity and depreciation in quality had so far progressed that some action became necessary. Accordingly, 118 more wells were driven, 53 in a line west of the lower station and south of the Boulevard, and the remainder in two radial lines, starting from a common point on the north side of the Boulevard. About 450 wells in all are now available for use in this field.

As in the other wells at this location, $2\frac{1}{2}$-in. extra heavy iron pipe was used, with a bottom section 38 in. long, perforated by one hundred and eighty $\frac{1}{2}$-in. holes, and having a spiral groove with a pitch of 1 in. cut into it, in which a brass wire is soldered for the purpose of maintaining a space of $\frac{1}{8}$ in. between the gage and pipe. The cast-iron well point into which the bottom section is screwed has a diameter of $4\frac{1}{8}$ in. and serves to make a larger hole than the well pipe, and so protect the strainer during driving. The strainer is of brass, perforated by longitudinal slots, there being twenty slots per inch horizontally and six per inch vertically.

The wells are driven by heavy drop hammer; a wash pipe is not used.

Each well pipe extends to the surface of the ground, where it is capped, a tee being inserted at the elevation of the suction main, to which it is connected by $2\frac{1}{2}$-in. iron pipe, a flanged end gate valve being inserted to enable each well to be cut off, and the connection with main being a screwed joint in a boss cast on the

FIG. 1.
CLEANING DRIVEN WELLS AT LOWER BOULEVARD PUMPING STATION.

FIG. 2.
PUMPING STATION.

latter pipe at an angle of 45 degrees. The wells are staggered 12 ft. apart on either side of the suction main, and 4 ft. therefrom, the main being laid with a grade rising to the air chamber, and at a depth sufficient to keep it below frost.

The material in which the wells are driven is relatively fine, so fine that the ordinary open end well cannot be used, and such that a strainer to keep out the smallest particles of sand is necessary. As a result, these strainers naturally clog, and as is found when the well pipes are pulled up, the space between the gauze and the pipe is filled with a sediment composed of the finest sand and compounds of ferrous iron and organic matter. A similar deposition, presumably, also takes place in the surrounding soil, but lessening in degree with increasing distance from the well.

On several occasions investigation has shown certain wells to yield no water because of the clogging just described, and these were pulled up and new wells redriven in a new location. Frequently, also, the entire system has been cleaned by shutting off the individual wells, removing the cap, and working up and down a wire bristle brush until the interior was clean, and alternately pumping and pouring in water until the supply came clear (Plate I, Fig. 1). In 1909 the most which could be drawn from the wells in March, after cleaning, was 5 000 000 gal. per day, but in April, after a four days' shut-down, 6 000 000 gal. could be easily drafted, indicating a capacity for recovery by rest which is of considerable interest.

A large percentage of the water undoubtedly comes from the adjacent river, and as the character of the underlying sands varies in porosity, the velocity of the subsurface flow and the purifying action is not uniform in all sections, and the quality of the water drawn from different wells, as a result, differs greatly. That the water, in great part, comes from the river, is evident by the seasonal changes in temperature, which are more pronounced than in a true ground water supply, and range between 45 degrees in winter and 65 degrees in summer.

The Merrimac River contains a considerable amount of organic matter, and this water, while purified to a degree where it is bacterially safe, is not filtered under the conditions necessary for complete chemical purification. Passing at varying velocities

through sands of different character, as already stated, there are sections where the rate of filtration is so high that the oxygen available in the water or soil is not sufficient to oxidize the organic matter originally in the water or taken up in passing through the river bed, and as a result, the iron oxides existing in the sand deposits are robbed of their oxygen and reduced to soluble form. That the quality of the water varies greatly in different parts of the field is known by examination of the supply for individual wells, and in 1909, 68 of the old wells were shut off because of excessive iron.

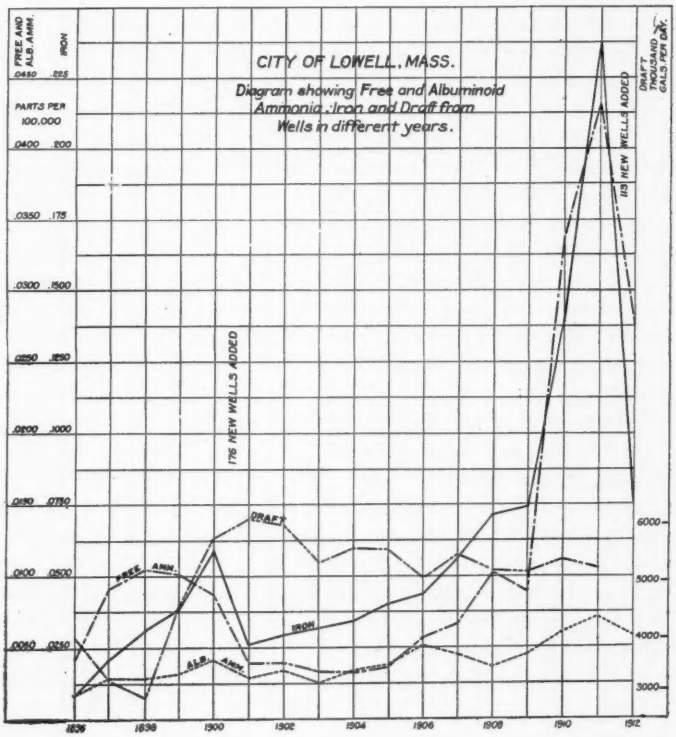


FIG. 2.

Iron in solution will always result when the oxygen originally in the water or made available during the process of filtration is not sufficient to oxidize the organic matter in the water or that which has gradually accumulated in the filtering medium. Increased distance between the stream and the well furnishes assurance of greater uniformity of rate in different sections, and a more complete purification, but the latter only if, by the increased distance, additional oxygen is made available. It is only by keeping the rate of filtration so low that the available oxygen will be sufficient to purify the organic matter that deterioration of the supply can be prevented, and this deterioration, as is proved by experience at Lowell, is progressive with prolonged use, and without material increase in the rate at which the water is drawn through the ground.

The diagram (Fig. 2) showing the amount of ammonias and iron in relation to the daily draft indicates this progressive deterioration in quality. From 1896 to 1900, the iron increased from .0098 parts per 100 000 to .0591 parts, but with the addition of 177 new wells, in 1900–1901, it dropped back to 0.0260 parts. From this figure it gradually rose to .2379 in 1911, but fell to .0793 as an average for 1912, partly because of the 118 additional wells placed in service during that year. In the first month of using these new wells, the iron was as low as .0020, but after four months' service it has risen to .0350. That these conditions are not due to increasing draft is proved by reference to the curve of consumption (Fig. 3), indicating the present use to be 10 per cent. less than the consumption of ten years ago, although the population has in the meantime increased about 10 per cent. At the present time the consumption is approximately 50 gal. per capita, the reduction having been due to the extension of the meter system.

It is to be noted, however, that the consumption in the maximum month sometimes rises to 30 per cent. in excess of the average for the year, and that this increase, coming as it usually does at the time when the supply is at the lowest point, is a more important factor where the water is drawn from the ground than in the case of a surface supply with large storage in reserve. It should also be noted, in considering the quality of the supply during recent

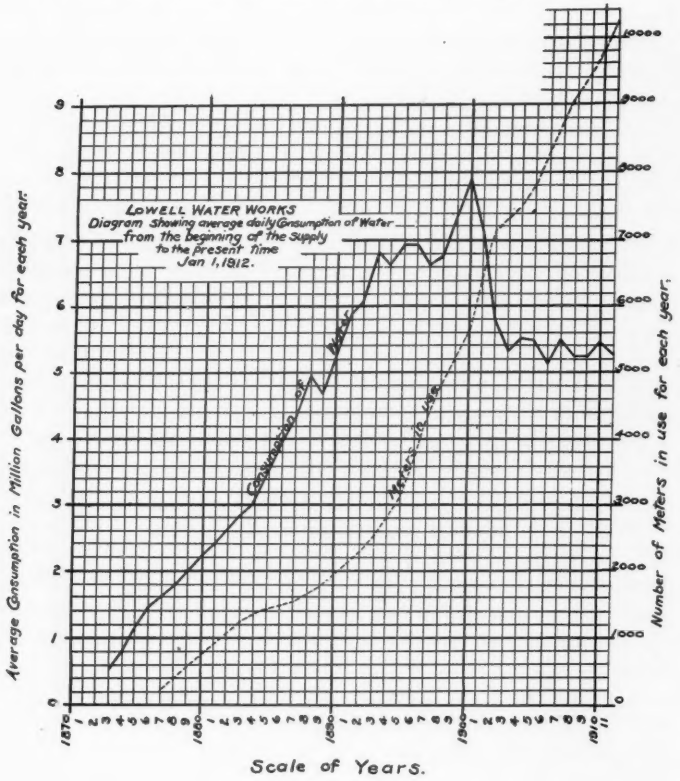

LOWELL WATER WORKS
Diagram Showing average daily Consumption of Water from the beginning of The Supply to the present Time Jan 1, 1912.
Consumption of Water
Meters in Use
Average Consumption in Million Gallons per day for each year.
Number of Meters in use for each year.
Scale of Years.

FIG. 3.

years, that the rainfall and run-off in these years has been much below the average, as is indicated by the following figures.

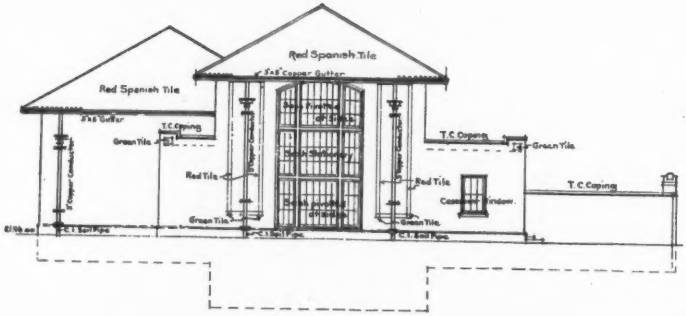
Year.	PER CENT. OF AVERAGE.	
	Rainfall.	Flow of Merrimac River.
1908	83	75
1909	93	65
1910	79	68
1911	90	61

Coincident with the development of iron in the well water, the fungus Crenothrix has been unpleasantly in evidence. It is found in the wells, conduit, pump well, and distribution system, imparting color, taste, and odor to the water, particularly where stagnant in dead ends, and causing stoppage in house connections when dislodged by any marked change in velocity of flow through the pipe system.

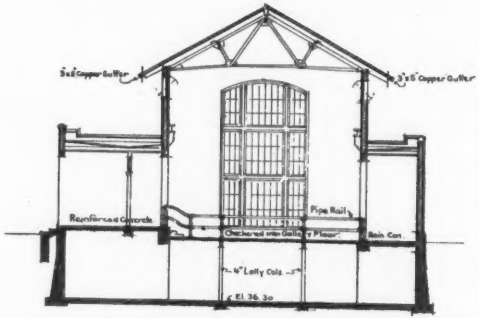
It is obvious that the iron is the undesirable factor in the present supply, and it is equally obvious that the remedy, if this supply from the ground is to be continued, is either to so extend the well system that the rate of draft from the river per unit of filtering area will be sufficiently low that the available oxygen will effect purification, or else to aërate and filter the ground water at high rates before supplying it to the consumer. In regard to the latter possibility, it is to be noted that because of the fineness of the sand and the fact that only in certain sections are the subsurface conditions suitable for driven wells, there may be some question as to the ultimate quantity which can permanently be drawn from the area adjacent to the river.

Another possibility of bettering the quality and increasing the quantity of water obtainable from the present well system is the intermittent pumping of the river water in small quantities on areas suitably prepared adjacent to the wells, and, by slow percolation through the sand lying between the surface and the well point, effecting purification, as is done in a number of places in this state. Should this not prove feasible, because of the difficulties of winter management, the final result at some time in the future may be the filtration of Merrimac River water. Without much doubt, the Lowell supply has been obtained up to the present time at less cost than would have been possible by filtration of the river water, and perhaps a further development of the present system may meet future requirements, but it is obvious that before long something must be done to better the quality of the supply. In any event, whatever the final method adopted, the pumping station just constructed will serve a good purpose, as the supply will be obtained from the same location, and the new covered reservoir will be equally as necessary as under present conditions.

The old station at the Lower Boulevard plant was a wooden



~EAST ELEVATION~



~TRANSVERSE SECTION~

FIG. 4.
PUMPING STATION.

structure, involving considerable fire risk in the housing of the machinery on which the supply was largely dependent. In 1908 an 8 000 000 gal. Holly, vertical, triple-expansion engine had been put in service, and as by test duty the engine had developed 120 000 000 ft.-lb. per 1 000 lb. dry steam, and was yearly saving in fuel $8 000 over the cost of operating the apparatus previously in use, or sufficient to return its cost in less than four years, practically all of the pumping was being done with this more economical engine,

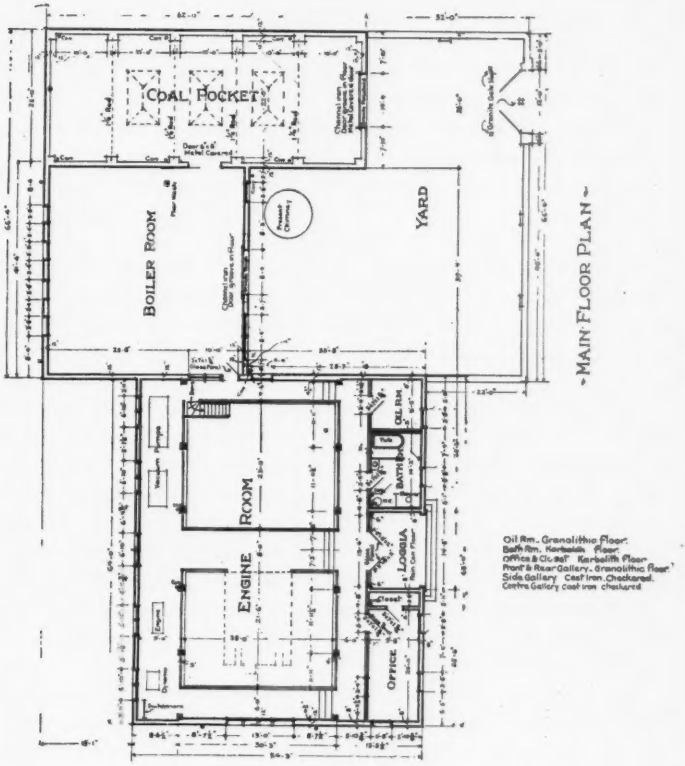


FIG. 5.

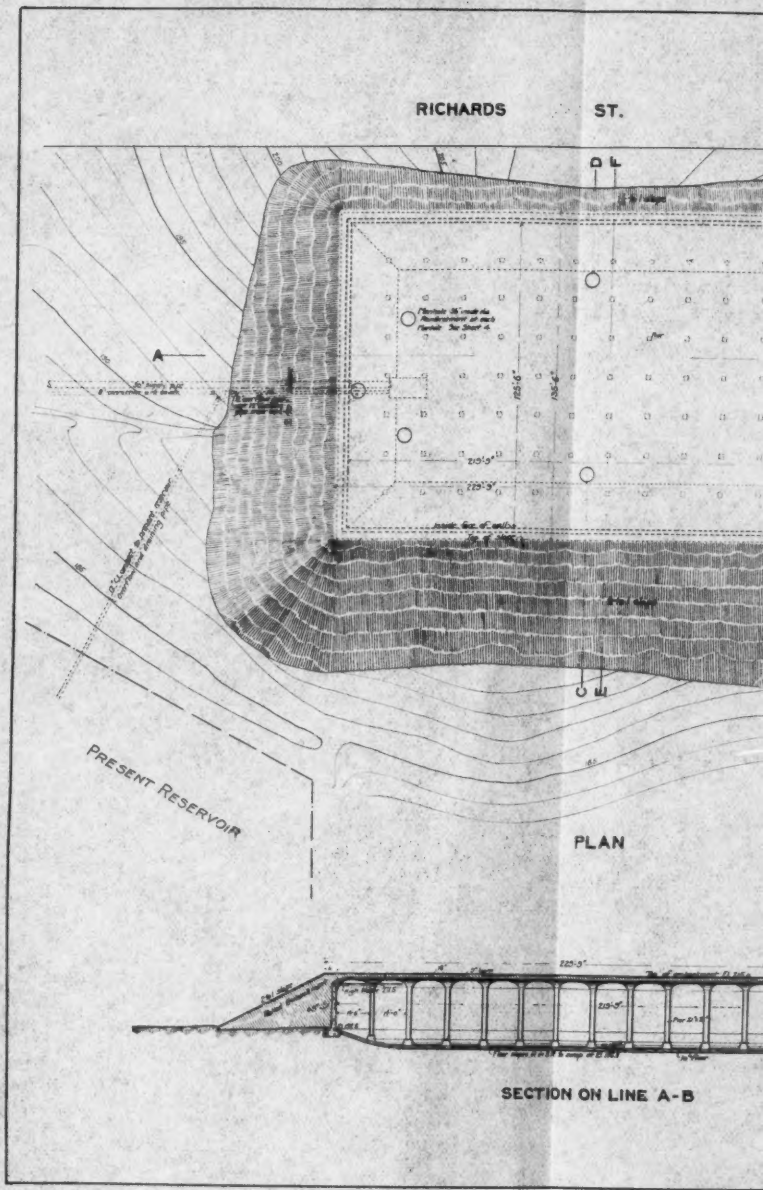
LOWELL WATER WORKS PUMPING STATION.

and it appeared advisable to provide a better building for its housing.

The new station (Plate I, Fig. 2), which has just been completed, is of hollow tile, plastered inside and outside with cement mortar, white quartz sand being used in the outer coat. The building, which includes an engine room, boiler room, and coal shed, is plain in design, but, with its white walls and red tile roof, is believed to be well adapted to its location on the Boulevard, with the river for a background. A wall encloses a yard and serves to tie together a rather disjointed ground plan, due to the necessity of adapting the layout to the old wooden station, over which the present building was erected. In order that the Holly pump might be kept in operation, the walls and roof of the new station were constructed before the dismantling of the old station began. The contract also included the resetting of the boilers, which were moved to a new location, and the tearing down of several old engine foundations. The contract price was $22 494, of which probably $2 500 is chargeable to dismantling of old work, making the net cost of the new building about $20 000, or 14 cents per cubic foot of volume. A feature of the building is the cross section of engine room, with a short span for the main portion, and with alcove projections for office, bathroom, oil room, and small auxiliary machinery.

The construction of the new reservoir was undertaken with the object of raising the pressure in the distribution system, and also to provide for storage of the ground water without exposure to light, and so prevent the growth of organisms giving rise to tastes and odors. In 1911, the old Morris pumping engine having become expensive to operate, an Allis Chalmers 8 000 000 gal. vertical, triple-expansion engine was put in service at the Centralville pumping station, and adapted to the pumping of water to the greater pressure which would result from the development of storage at a higher elevation.

The reservoir, which has recently been completed, was located near the open reservoir on a lot already owned by the city, in order to save the expense of acquiring additional land. Its water line at elevation 211.5 was made as high as possible within the limits of this land, and at the same time balance excavation and embank-


RICHARDS ST.
A
B
PRESENT RESERVOIR
PLAN
SECTION ON LINE A-B

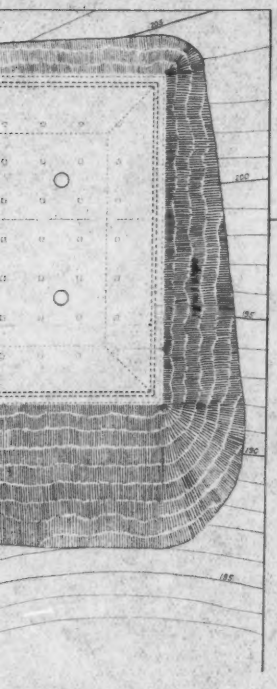
LOWELL WATER WORKS

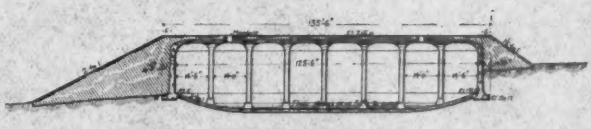
COVERED DISTRIBUTING RESERVOIR

GENERAL PLAN & SECTIONS

Scale 1 inch = 20 Feet.
November. 1911.

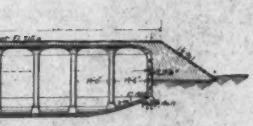
F. A. Barbour
Engineer



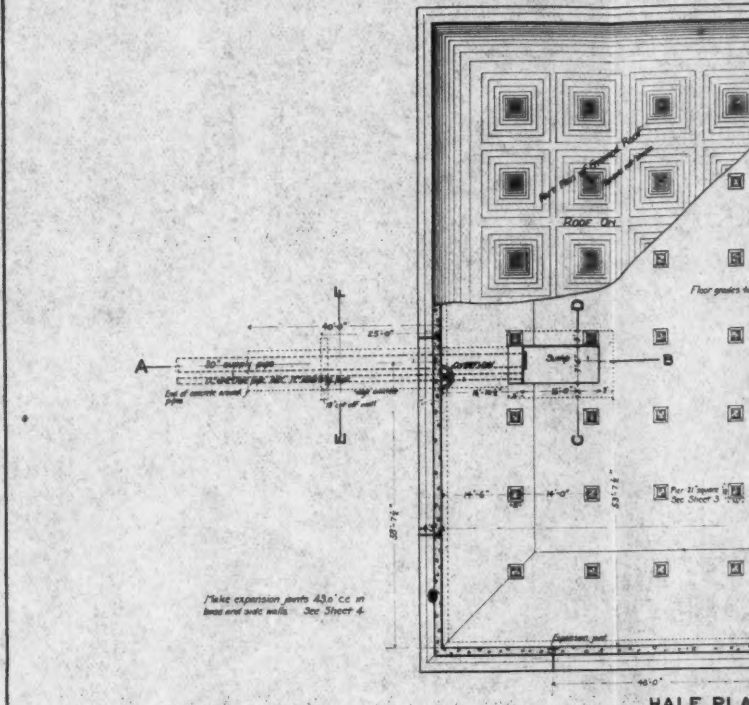


SECTION ON LINE C-D

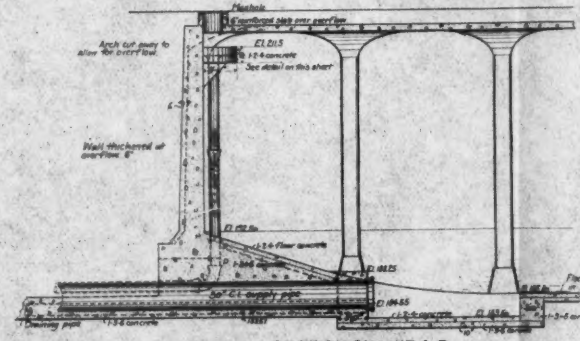
SECTION ON LINE E-F



SHEET 1



HALF PLA
Scale 1 inch = 10 f



SECTION ON LINE A-B
Scale 1 inch = 5 feet

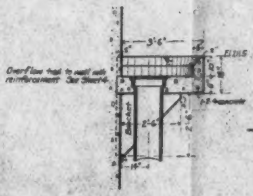
LOWELL WATER WORKS

COVERED DISTRIBUTING RESERVOIR

HALF PLAN OF RESERVOIR AND DETAILS OF OUTLET PIPING AND OVERFLOW

November, 1911. F. A. Barbour, Engineer.

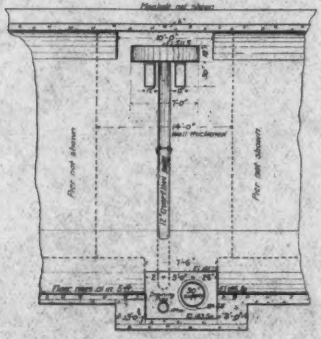
PLAN
= 10 feet



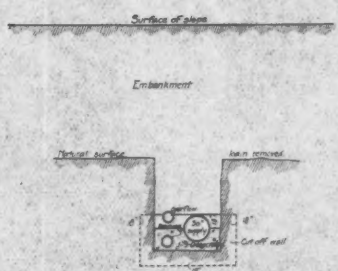
SECTION ON CENTRE LINE.

PLAN

DETAIL OF OVERFLOW BOX
Scale 1 inch = 2 feet.

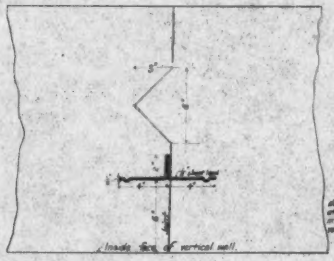


SECTION ON LINE C-D
Scale 1 inch = 5 feet

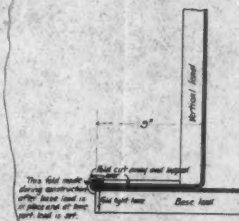


SECTION ON LINE E-F
Showing Reinforcement of Pipe under Embankment.
Scale 1 inch = 5 feet.

SHEET 2

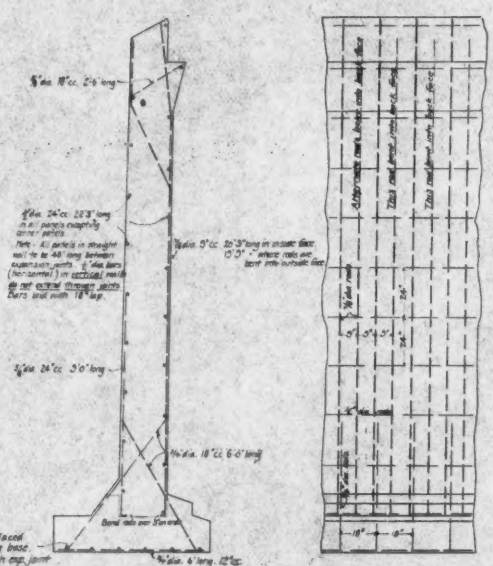


Plan.
Scale ½ Full Size.



Method of connec
Vertical Wall and Foun
Scale ¼ Full Size

DETAIL OF EXPANSION JOINTS


⅝"dia. 18"cc. 2'-6" long
¾"dia. 24"cc. 12'-3" long in all panels excepting corner panels
Note - All panels in straight walls up to 48' long between expansion joints. ¾" dia. bars (horizontal) in vertical walls do not extend through joints. Bars laid with 18" lap.
¾"dia. 9"cc. to 3'long in inside face 1'-3" " where rods are bent into outside face.
⅝"dia. 24"cc. 3'-0" long
⅝"dia. 18"cc. 6'-0" long
Bend rods over 3'on end
⅝"dia. 12"cc. placed continuously in base. Extend through exp. joint. Laid with 18" lap
⅝"dia. 6' long. 12"cc.

- Section of Wall -

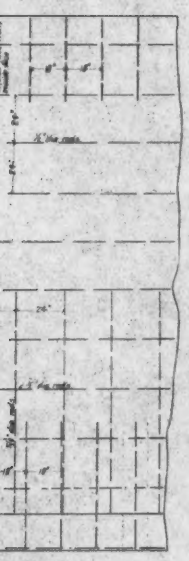
- Inside Face Wall -

- Outside F

REINFORCEMENT OF SIDE WALLS
Scale 1 inch = 2 feet.

connecting
nd Foundation Leads.
full size

INTS.



tside Face Wall.

Sect. of Wall
Scale, 1in = 4 F

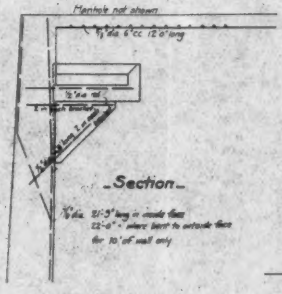
LOWELL WATER WORKS

COVERED DISTRIBUTING RESERVOIR

PLAN SHOWING STEEL REINFORCEMENT AND DETAIL OF EXPANSION JOINTS

November. 1911 F A Barbour. Engineer

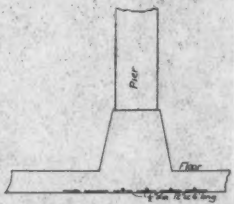
Reinforcement around Manhole.

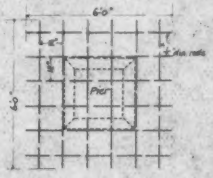


Section

Plan

REINFORCEMENT OF OVERFLOW
Scale 1 inch = 2 feet.





Reinforcement under Piers
Scale 1 inch = 2 feet

SHEET 4

ment. The structure, which is part in excavation and part in embankment, is of concrete, 219.75 ft. long, 125.5 ft. wide, with a depth of 24.0 ft. from the top of the floor to the springing line of the arched roof, and has a capacity of approximately 5 000 000 gal.

The floor is of plain concrete, 10 in. thick, laid in two layers, breaking joints, the lower layer a 1:3:6 mix, and the upper a 1:2:4 mix. The floor rises with a slope of 1 vertical to 3 horizontal from the general level of the bottom to the base of the side walls, lessening the necessary height of these walls to 17.5 ft. above the base, as compared with 24 ft. height of piers, and effecting a material saving in the cost of reservoir per unit of capacity. The material excavated was a hardpan, practically impervious, and incompressible. The floor was, therefore, made a plain slab, without reinforcement, except under the piers, where $\frac{1}{2}$-in. rods in both directions, spaced 12 in. on centers and 6 ft. long, are placed near the lower surface.

The walls are of concrete, reinforced vertically on inside surface as a beam, supported at the top by the roof and at the bottom by the floor, but with an outside and inside projection of base and such reinforcement as a cantilever as would permit backfilling of the wall to a height of 15 ft. before the floor and roof were placed in position, thus enabling 70 per cent. of the total excavation to be deposited in final location at the time of first handling. The base was first placed, and the concrete in walls was then constructed in sections 40 ft. long to the full height, with expansion joints formed of a folded sheet of lead between each section, and with sufficient horizontal reinforcement for temperature stresses to prevent cracking between these joints.

The reinforcement for temperature is carried around the corners, and the first expansion joint is located 20 ft. each side of the corners. The lead sheets $\frac{1}{8}$ in. thick and 8 in. wide projected into the concrete 4 in. each side of the joint, with a fold of 2 in. at right angles to the wall and in the plane of the joint between the sections. The joint in the concrete extended down through the base, but the steel in the base was placed continuously, while that in the walls stopped each side of the expansion joint. Before the completion of the structure, and when the temperature of the air had approached 40 degrees, all of the expansion joints had opened, a

straight line extending from the top to near the base of the wall, and varying in width from a hair crack to $\frac{1}{16}$ in.

The walls are 24 in. thick at the base, and 18 in. thick at the springing line, with a projecting lip 6 in. wide to catch the arch concrete of roof and reduce to 14 ft. the span of the outside cylindrical section.

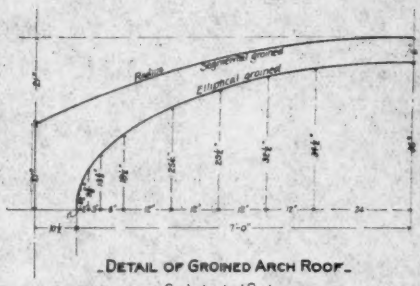
The concrete in base of walls is a 1:2½:5 mix, and above the connection with floor, a 1:2:4 mix. For size and spacing of the steel in walls, reference may be made to the plans.

The piers are 21 in. square, with a base 2 ft. 6 in. high and 3 ft. square at the bottom, constructed of plain concrete, mixed in the proportion of 1:2:4. The piers above the base were built to the full height at one filling of the forms, and no difficulty was found in properly joggling the material to place in this depth of form, nor in maintaining the forms to true lines.

The roof is of the groined arch type, with clear spans of 14.0 ft., a rise of 36 in., a thickness at crown of 6 in., and a depression over the piers 21 in. deep. The under side of the arch section is elliptical, the upper surface segmental.

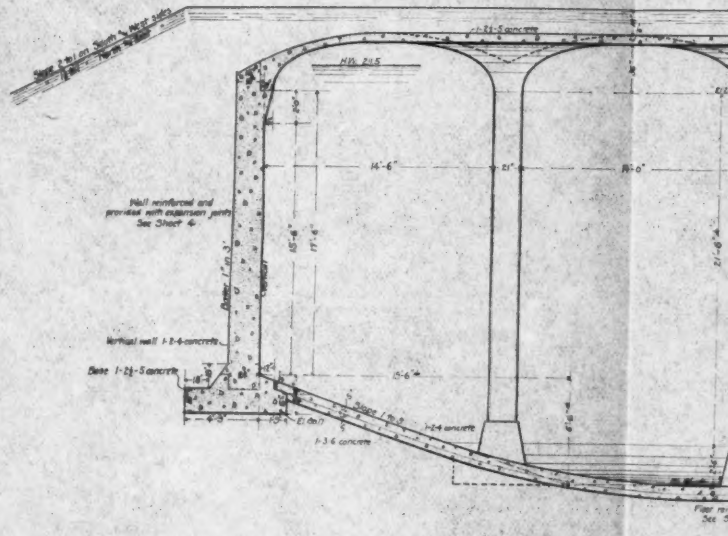
A single 30-in. cast-iron main extends from the pipes leading to the old reservoir, being cross-connected to both force mains and the supply pipe to the distribution system, and serving as both inlet and outlet for the new reservoir. A check valve was placed in the outlet pipe from the old reservoir, thus automatically bringing this reservoir, which it is proposed to keep full and in reserve, into service, should the pressure drop below that, due to its flow line. A large concrete gate chamber was constructed to contain the several gates at the junction of the new and old mains. The 30-in. pipe ends at a point a few feet inside the new reservoir at the present time, although the plan of floor and sump is such that a branch may be inserted and the line extended to the further end of the structure, and the necessary check valves provided, so as to insure circulation, should this prove necessary.

The floor of reservoir slopes to a sump, from which a drain pipe leads to a sewer. A circular concrete overflow weir, bracketed to the end wall with discharge pipe which cannot be closed, prevents the water being raised higher than the intended level, the overflow discharging into the nearby uncovered reservoir.



DETAIL OF GROINED ARCH ROOF

Scale 1 inch = 1 foot



PART SECTION BETWEEN PIERS

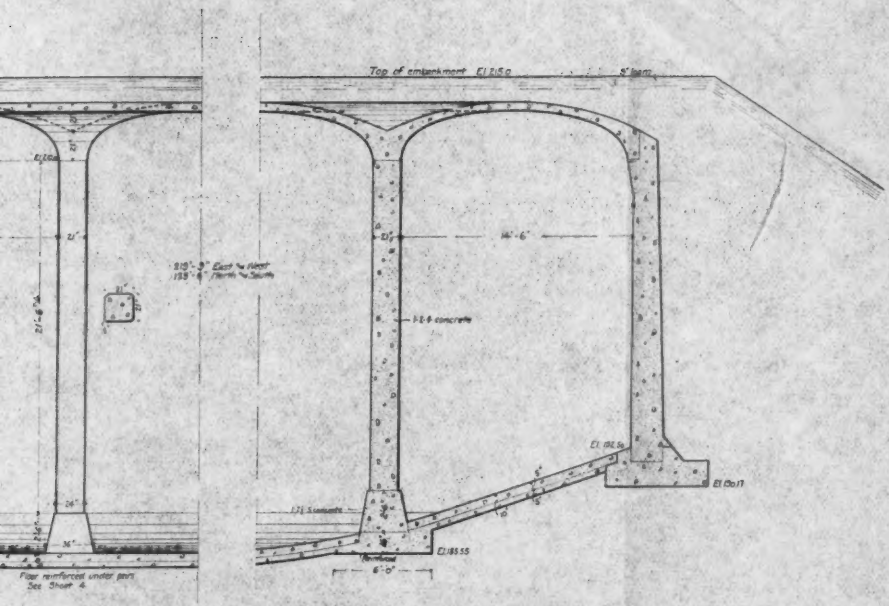
LOWELL WATER WORKS

COVERED DISTRIBUTING RESERVOIR

SECTION OF RESERVOIR & DETAIL OF GROINED ARCH

November 1911

F A Barbour
Engineer



PART SECTION THROUGH PIERS

Scale 1 inch = 3 feet.

SHEET 3

As a matter of public policy, it was thought wise to do all excavation and construct the embankments by day labor. The reservoir was so placed as to balance excavation and embankment, the total quantity of earth work amounting to 15 600 cu. yd., of which 4 800 cu. yd. were spoiled and handled a second time. The cover over the roof, including the loam, is 18 in. deep, the shoulders of the embankment are 6 ft. outside of the inside face of the wall, and the slopes of all high embankments are 2 horizontal to 1 vertical. The 30-in. force main and the construction of the gate chamber at old reservoir were also done by city labor, and the gang was so frequently shifted that no attempt was made to keep a force account of the actual cost of earth work at reservoir.

The masonry work was let by contract to Cyrus Barton, of Lowell, the lowest bidder. Excavation was begun in the fall of 1911, but no concrete was placed until the spring of the present year. The design of the walls, as already stated, provided for the placing of the backfilling at the time of first handling. Accordingly, the first excavation was along the line of the walls to give opportunity for their construction, the core being left for subsequent removal, as the building of the walls provided a place to deposit the material without resort to spoil banks.

The contract prices for masonry were as follows: Concrete in floor, $5.50 per cu. yd.; concrete in wall, $7.95 per cu. yd.; concrete in piers, $10.00 per cu. yd.; and concrete in roof, $9.00 per cu. yd. These prices do not include the steel reinforcement, which was furnished by the city, nor the cement, furnished by the contractor, but paid for separately at the rate of $1.45 per barrel.

The cost of the reservoir, exclusive of excavation and embankment, was somewhat less than $6 000 per million gallons of capacity.

Some requirements of the specifications in regard to concrete may be of interest. Cement was to fulfill the specification of the American Society for Testing Materials; sand was to be in appearance very coarse, but to contain sufficient fine grains to reduce the percentage of voids to a minimum; and the coarse aggregate was to vary in size of particle from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in diameter. In mixing concrete, the right was reserved to change the proportion of sand and coarse aggregate, in order to reduce the

voids so far as possible. The consistency of the mixture was to be such that it could be placed by joggling and spading, but with little or no ramming. Too much water was to be avoided, and the concrete was not to be so wet that there would be a tendency for the coarse aggregate to settle through the mixture. At all horizontal joints beveled bonding pieces were placed, the joints scrubbed with steel wire brushes to expose the aggregate before final set of the concrete occurred, and before placing additional concrete, the joint was thoroughly flushed with water.

Particular attention was paid to the requirement that all concrete should be kept wet for one week after placing, sawdust being spread over the floor and burlap hung over the walls, and both kept saturated with water. It is believed that this provision of ample water to prevent drying out of the concrete is most important in eliminating shrinkage cracks during setting.

The reservoir has been in service since December 6, 1912.

The design and construction of the reservoir, as well as the new pumping station, was in charge of F. A. Barbour, consulting engineer, of Boston, to whom the writer is materially indebted for this paper.

DISCUSSION.

MR. THOMAS. I suppose the part of the paper most interesting to the members is that relating to the driven wells. In Lowell at the present time we are pumping 5½ million gallons from wells. Owing to the addition of new wells last year the iron content is comparatively low, but we believe that as the wells are used it will rise. The question with us, and I suppose the question is the same with other communities which are supplied with driven wells, is, What can be done to prevent the iron content becoming so large as to make the water unsuitable for laundry and certain manufacturing purposes?

In a paper read before the Association some two or three years ago it was suggested that by shutting off the wells and discontinuing their use for a year or two, the water might go back to its former condition; but I think that is very doubtful. I do not believe that that suggestion was based on experience to any great extent, and probably many of our opinions are simply theories and not

FIG. 1.
THE RESERVOIR UNDER CONSTRUCTION.

FIG. 2.
INTERIOR VIEW OF RESERVOIR.

based on practical experience or any demonstration we have of the truth of them.

On the bank of the river only a mile further down the stream from where our wells are, a filter gallery was built in the early days of the water works, as stated in the paper. The water from it was so much cooler than the river water, and so much purer bacterially and chemically, that it was thought to come from the land side. But after ten or a dozen years the water became so foul, so high in iron, and the Crenothrix grew so profusely in it, that the city had to cut it off, and it remained for about ten years without being used. Last summer we turned the water on to the filter gallery for about two weeks, but we were forced to shut it off again because it was almost as bad as it was ten years previously.

It seems to me that this case is analogous to a driven well. Undoubtedly the water was coming from the river. The water looked splendid in the filter gallery when we let it on for several days but it deteriorated rapidly. Now, would not the result be the same in the case of wells that are shut off?

The question, therefore, is as to the treatment of the water. We can get a sufficient quantity of water, but the question is to improve the quality, to eliminate the iron content. Without doubt a great many present have had experience and can give some information in regard to the probability of treating the water so that it can be used.

Mr. F. F. Forbes.* We have had some trouble in Brookline. If we draw too heavily on our wells, the iron increases quite rapidly. We have made some experiments to remove the iron by filtration and we have found that we can remove a large part of the iron, 60 to 75 per cent., simply by aërating and letting the water stand a little while to settle and then filtering it. We may have to filter all our water in that way in order to remove the iron.

Two or three years ago we were drawing heavily on our wells and the iron increased nearly twofold. After the additions were made so that we could draw less heavily on the wells, the iron was reduced to .02 or to .03 in 100 000. We have been using our filter gallery for nearly thirty-eight years, and the water in the gallery is as good as it ever was.

* Superintendent Water Works, Brookline, Mass.

MR. ROBERT S. WESTON.* Mr. President, I was very much interested in the paper on the Lowell supply, and especially in the curve which showed the increase of iron in the wells from time to time, followed by decreases when the wells were extended; and I was interested this morning in looking up some of my office records to see how general that experience had been throughout the state.

I found some fifteen or twenty places in Massachusetts supplied with ground water which contained iron. For instance: Billerica, Bridgewater, Cohasset, Dedham, Fairhaven, Hyde Park, Kingston, Lowell, Methuen, Middleboro, Newton, Provincetown, Walpole, Ware, Waltham, Winchendon, Webster, Wellesley, and Woburn. In the beginning in nearly all these places the water contained only a small amount of iron. For instance, in Billerica the iron was only .2 parts per million in 1900, and in 1911, .45. In Bridgewater there was an increase during the period from 1900 to 1906, when the wells were extended, and at the present time the iron is just a little above the permissible limit. Brookline, Mr. Forbes has already told you about. Dedham had no iron in the ground water in 1895, and at present, while there has been an increase of 128 per cent., it is still below the permissible limit. At Fairhaven, Walpole, Ware, and Wellesley, there has been no increase in the iron, but in all these places the area supplying the water is very large in proportion to the consumption, — either the number of wells is large or the wells are in a gravel containing little iron, which yields water very readily. The wells at Lowell between 1895 and 1911, as Mr. Thomas has told you, show an increase to nineteen times the amount of iron that there was in the beginning; those at Brookline, twenty-three times; those at Middleboro, six times; while those at Methuen have increased 168 per cent.; Hyde Park, 437 per cent., and so on. These data are shown in the table on the following page.

It seems that it is almost the rule where ground waters are taken from beneath water-bearing strata which contain bog-iron ore, that sooner or later the iron in the water is bound to increase to a dangerous amount. This is because, as is generally known, the iron is insoluble when there is plenty of oxygen present, but by drawing heavily on the wells the amount of oxygen is exhausted

* Consulting Sanitary Engineer, Boston, Mass.

IRON IN SOME MASSACHUSETTS WATERS.

Parts per Million.

TOWN.	YEAR.									
	1895.	1900.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.
Billerica	.....	0.252	0.432	0.463	0.414	0.362	0.428	0.448	0.450	0.478
Bridgewater	.....	1.377	0.963	1.552	1.100	0.682	0.876	0.412	0.428	0.340
Brookline	0.022	0.068	0.215	0.218	0.287	0.208	0.235	0.465	0.546	0.385
Cohasset	.....	.....	0.300	0.130	0.155	0.150	0.147	.....	.....	.....
Dedham	0.000	0.039	0.055	0.083	0.090	0.043	0.072	0.065	0.089	0.073
Fairhaven	0.138	0.130	0.115	0.202	0.148	0.128	0.135	0.063	0.077	0.120
Hyde Park	0.149	0.340	0.684	0.859	0.720	0.769	0.830	0.783	0.801	.....
Kingston	.....	0.180	0.027	0.030	0.070	0.018	0.120	0.050	0.120	0.086
Lowell	0.119	0.591	0.402	0.439	0.562	0.715	0.743	1.393	2.379	0.836
Methuen	0.133	0.223	0.580	0.365	0.336	0.319	0.366	0.238	0.357	0.887
Middleboro	0.187	0.489	1.170	1.126	1.209	1.349	1.221	1.572	1.598	1.509
Newton	.....	0.029	0.137	0.080	0.063	0.053	0.075	0.097	0.043	0.057
Provincetown	.....	3.774	6.930	6.787	9.750	7.900	7.842	0.056	0.115	0.063
Stoughton	.....	0.047	.....	0.153	0.110	.....	.....	.....	.....	0.123
Walpole	.....	0.146	0.032	0.068	0.077	0.036	0.051	0.053	0.043	0.053
Waltham	0.082	0.086	0.437	0.439	0.744	0.290	0.478	0.575	0.387	0.375
Winchendon	.....	0.112	0.620	0.627	0.660	0.932	0.777	0.970	1.077	0.115
Ware	.....	0.042	0.070	0.090	0.068	0.032	0.059	0.055	0.037	0.038
Webster	.....	0.036	.....	0.160	0.106	0.092	0.114	0.208	0.092	0.117
Wellesley	.....	0.060	0.055	0.072	0.059	0.053	0.059	0.043	0.043	0.047
Woburn	0.023	0.032	0.038	0.035	0.028	0.032	0.034	0.030	0.047	0.046

in burning the organic matter in the soil, and as a result of that process of burning, carbonic acid is produced, and this carbonic acid dissolves the iron. All water-works men know that most iron waters are perfectly clear when first drawn from the ground, but when they are allowed to stand they become, first turbid, then this turbidity becomes red, and finally, if allowed to stand long enough, the red turbidity, which is nothing more nor less than iron rust, settles out and leaves the water above the sediment perfectly clear and practically free from iron.

The only way to remove iron is to get it into an insoluble condition. This is usually accomplished by rusting, — that is, exposing the water in a very thin layer to the action of the oxygen in the air. This will wash out the carbonic acid and make the iron insoluble, and, what is more, get it into particles which are large enough to be strained out subsequently by a sand filter.

Sometimes, where there is a great deal of organic matter from peat bogs, or from other sources, some additional treatment with chemicals is necessary. I am now making some experiments for the Cohasset Water Company, where the amount of organic matter is so high that chemicals may have to be used. The amount of chemicals necessary to be used with such waters as these can be greatly reduced, if their use may not be avoided, by not only aërating the water, but also exposing it to contact with some of the iron which has been precipitated previously. This is accomplished by spraying the water over a pile of coke, gravel, or No. 2 road metal, — that is, material $\frac{3}{4}$ to $1\frac{1}{2}$ in. in diameter. This soon collects a film of iron rust; this moist iron rust attracts the fine iron in the water to it and holds it there until it is oxidized and coagulated. The moist rust accumulates on the stones up to a certain point, then it sloughs off and passes on to the settling basin, where it is removed quite readily and does not clog the filter rapidly. It does not make much difference whether one uses a mechanical filter or a slow filter to remove iron from a ground water. The main thing is to get the iron oxidized and coagulated sufficiently before it is filtered. If you filter water without sufficient pre-treatment, the period between scrapings, or between washings, will be so short that the cost of treatment will be very high.

Out at Superior, Wis., in 1908, we made some experiments to see what was the best method of removing iron from the well water. These wells were located on the island which separates the harbor from Lake Superior, — simply a place where the débris brought down by the very highly colored St. Louis River was thrown up by the action of the waves of Lake Superior. Into this pile, the result of the accumulation of floating organic matter, woody fiber, sand, etc., wells were driven, and the water from these wells was brought across the bay to the pumping station on the mainland. As soon as all these wells were started, all the usual troubles due to the presence of iron were noticed, and it was found that filtration of the water was necessary. A filter was built and the trouble was removed. In this filter the aëration was very thorough, but it was soon found that in this case the organic matter formed a combination with the iron which was extremely

difficult to remove, and the aëration had to be carried just far enough so as to oxidize the iron and not far enough to permit this compound of iron and organic matter to be formed.

I have had a number of experiences of this kind, and I think I can say without any question that all the problems are capable of solution, but the treatment that is essential in one case, and adequate in one case, will not necessarily work in another, due, as I have just said, to differences in the amounts of organic matter and gases present in the water in combination with the iron.

MR. R. D. CHASE.* When that Superior plant, of which Mr. Weston has spoken, started, the water showed up very nicely. So far as the consumers were concerned, however, they could not seem to see that the filter was of very much use, for the water did not appear to them to be any better, but, in fact, decidedly worse. As near as we could make out, the Crenothrix had been growing very nicely in the water without oxygen, but as soon as the water was saturated with oxygen the growth died, fell off and was carried along in the pipes, so that the average householder, when he opened a faucet, would get something which was a fair imitation of thick tomato soup, and he did not like it. It took us some little time to find out just what was happening, and then a very considerable amount of flushing before we could convince the people in the town that the filtration plant was anything but a fake.

MR. WESTON. I would like to ask Mr. Thomas whether or not he has had any trouble due to the clogging of his strainers, because the iron oxidized in the strainers from being exposed to the air? I know that in some of the German plants they are very careful not to let any of their aërated water flow back through the pumps to the wells when they stop for the night, because the air rusts the iron in the well water in the bottoms of the wells and clogs the strainers.

MR. THOMAS. We had occasion to move about fifty of our wells, and we found that the space between the gauze and the well casing filled up with silt and iron rust. The first time we put in the wells, we took the skin of the iron and cut a groove in the shell to hold the gauze. The last two years we just cut a spiral groove, without disturbing the outside of the pipe, and put our gauze on

* New Bedford, Mass.

that. As I say, we found the space filled up full, without any apparent break in the strainer itself. We had the material analyzed by a local chemist and I believe he said it was composed mostly of ferric hydrate. That is about the only evidence we have. When we shut down, the water drains back into the wells from the receiver and from the pumps and the stretch of suction line, and for an hour or so after starting, in fact, for several hours after starting, we are unable to get as much water as we did before we stopped or when we were running right along.

BENDING TEN-INCH CAST-IRON PIPE.

BY CHARLES W. SHERMAN, PRINCIPAL ASSISTANT ENGINEER WITH METCALF & EDDY, CONSULTING CIVIL ENGINEERS, BOSTON.

[*Read February 12, 1913.*]

Probably many of the members of this Association would state as an unquestioned fact that it would be impossible to bend cast-iron pipe, and the remainder would admit that they had never heard of its being done. Seeing is believing, however, and the accompanying photographs (Plate VII), taken by Mr. Leonard Metcalf, show part of a line of 10-in. pipe in which there were about forty lengths which had been heated and bent.

This pipe is a part of the pipe line built for the United Fruit Company, conveying the Guayabo River water to the town of Preston, Cuba. For the greater part of its length it is laid upon the surface of the ground, so that it was possible to photograph the pipe, although it has been in use two or three years.

The canyon through which the pipe passes for about two miles from the dam is crooked, making impossible such easy curves as could be made in the pipe joints. Through somebody's oversight, no curves or sleeves were ordered with this pipe when it was bought; and as it might have taken a month or more to send up and get additional specials, the local engineer — not a water-works man — decided to bend some of the straight pipes. This had been done frequently with steel or wrought-iron pipes for the sugar mill, and they followed the same course of procedure with the cast-iron pipe, with entire success, as they did not break or spoil a single pipe. The pipes were bent to various radii, the shortest being 50 ft.

A cradle of old rails was first constructed with the desired amount of curvature. About one foot at each end of the pipe was left outside the fire, to prevent collapse of the pipe, and a fire of hard wood was built under and around the remainder of the pipes. Six or eight pipes were bent at a time. In one and one-half to

two hours after starting the fires the pipes were hot enough to bend, and settled from their own weight to the cradle prepared to receive them.

These particular pipes were 10 in. in diameter, with $\frac{9}{16}$-in. thickness of shell, corresponding to Class D of the New England Water Works Association Specifications, the weight of which is 760 lb. per 12-ft. length.

FIG. 1.

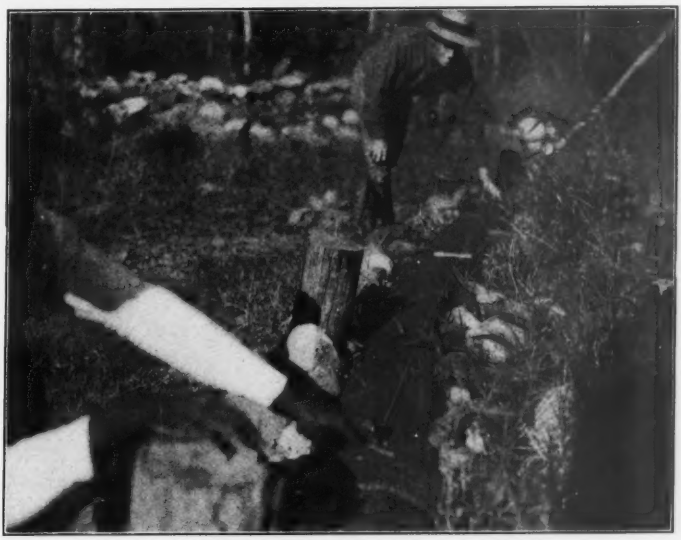


FIG. 2.

GUAYABO RIVER, CUBA, 10-INCH PIPE LINE TO PRESTON. BENT CAST-IRON PIPE, OCTOBER 7, 1913.

All members who have information pertaining to this report are urged to send it to the chairman of the committee, the Secretary, or the Editor. The report will be presented for discussion at the September meeting, and all discussions received will be published with the proceedings of that meeting.

REPORT OF COMMITTEE ON WATER CONSUMPTION STATISTICS AND RECORDS.

LEONARD METCALF, CHAIRMAN; FRANK J. GIFFORD, WILLIAM F. SULLIVAN.

[*Presented March 12, 1913.*]

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Scope of the Report.

On November 9, 1910, the paper upon "Water Consumption and Statistics Relating Thereto," presented by Mr. Edward S. Cole,* was referred to a committee of three, with the request that the committee give consideration to the most desirable revision of the forms used by this Association for gathering and reporting water consumption statistics and records. Subsequently the scope of the inquiry was broadened to include a discussion of the subdivision of water consumption and of the reasons for the wide variation in daily water consumption per capita found in our American cities.

On April 1, 1911, your committee sent out a circular letter asking for specific information concerning water consumption and rates upon the works with which the members of this Association were connected. The response to this circular was more or less desultory, and after a somewhat voluminous correspondence the committee concluded that it would be wiser and more effective to confine its efforts to getting information from a limited number of works, more or less typical in character, with the operators of which the personal relations of the members of the committee were such as to make it possible to gather reliable data. The data thus collected follow the recommendations contained in this report. They have been quoted at length in order that members might have at hand the essential facts upon which the findings of the committee have been based. Though in no sense complete, the data are believed to be sufficiently broad to be characteristic and significant.

Recommendations of the Committee.

The committee recommends the revision of the forms now used for reporting "Statistics of Consumption of Water" and "Financial Statistics," by the substitution of the following questions for Questions 1 to 12, page 7, and of the following items for Items A to M, page 5, of the "Blank Form for Summary of Statistics Adopted by the New England Water Works Association, September 11, 1902."

*Journal N. E. W. W. A., Vol. 25, p. 66.

PROPOSED REVISION OF "STATISTICS ON WATER CONSUMPTION," APPEARING UPON PAGE 7 OF BLANK FORM ADOPTED SEPTEMBER 11, 1902.

1. Year for which Report is Made.....
2. Population:
   a. Total.....
   b. On Line of Pipe.....
   c. Supplied.....
3. Total Number of Taps.....(Number of Live Taps.....)
4. Average Number of Persons per Tap.....
   (Found by dividing the Total Population [2*a*] by the Total Number of Taps [3].)
5. Total Number of Metered Taps.....
6. Per Cent. Metered Taps.....
   (Found by dividing the Total Number of Metered Taps [5] by the Total Number of Taps [3].)
7. How is the Total Water Consumption determined,
   a. By Meter upon Supply Main.....
   (Yes or no.)
   b. By Plunger Displacement of Pump.....Slip Allowed.....%
   (Yes or no.)
   c. By Other Methods. Describe.....

	Gallons.		Per Cent. of Total Consumption.
8*a*. Total Annual Water supplied for Domestic Uses:			
By Metered Services	.....	=	.....
By Fixture Rate Use	.....	=	.....
b. Total Annual Water supplied for Industrial Uses:			
By Metered Services	.....	=	.....
By Fixture Rate Use	.....	=	.....
c. Total Annual Water supplied for Public Uses:			
By Metered Services	.....	=	.....
By Fixture Rate Use	.....	=	.....
d. Total Leakage or Water-Unaccounted-for	.....	=	.....
e. Total Annual Amount of Water supplied	.....	=	100%

9. Amount of Water supplied:
   a. Total for the Year.....gals.
   b. Average per Day .....gals.
   (Found by dividing Total Annual Amount of Water supplied, shown in [8*e*], by 365* days.)

* Or 366 in case of Leap Year.

c. Average per Day per Tap.....gals.
(Found by dividing Amount shown in [8*e*] by Total Number of Taps shown in [3].)

d. Average per Day per Capita.....gals.
(Found by dividing Amount shown in [8*e*] by Total Population shown in [2*a*].)

10. Cost of Supplying Water, per Million Gallons, figured on Total Maintenance Item [*CC*].....$.....

11. Total Cost of Supplying Water, per Million Gallons, figured on Total Maintenance plus Interest upon Bonds.....$.....

12. Total Cost of Supplying Water per Million Gallons, figured upon Total Maintenance, Depreciation, and Interest upon the Fair Value of the Plant.....$.....

PROPOSED REVISION OF "FINANCIAL STATISTICS," SHOWN UPON PAGE 5 OF BLANK FORM ADOPTED SEPTEMBER 11, 1902.

Receipts from Water Rates.

A. Fixture Rates for		
a. Domestic Uses	$.....	
b. Industrial Uses	$.....	
c. Total		$.....
B. Meter Rates for		
a. Domestic Uses	$.....	
b. Industrial Uses	$.....	
c. Total		$.....
C. Public Uses for		
a. Hydrants	$.....	
b. Fountains	$.....	
c. Street Watering	$.....	
d. Public Buildings	$.....	
e. Miscellaneous Public Uses	$.....	
f.	$.....	
g.	$.....	
h.		
Total		$.....
D. Other Miscellaneous Uses:		
a.	$.....	
b.	$.....	
c. Total		$.....
Carried forward		$.....

Brought forward	$.....
E. General Appropriations	$.....
F. From Municipal Departments	$.....
G. From Tax Levy	$.....
H. From Bonds	$.....
I. From Other Sources	$.....
	$.....
	$.....
	$.....
J. Total	$.....

In the column of "*Expenditures,*" after the item "FF. Sinking Fund," add on the next line, "FFF. Depreciation Allowance."

At the foot of the page, after item "O. Net Cost of Works to date.....$.....", add the line, "OO. Estimated Fair Value of Works.....$....."

Water Consumption per Capita and per Tap.

The general data relating to water works, from which information was received, are contained in Table 1.

The replies to the circular letters sent out have been lodged in the library of the Association, in a volume entitled, "Report of Committee on Water Consumption Statistics and Records, 1910–1913, Leonard Metcalf, chairman; Frank J. Gifford, William F. Sullivan."

The per capita water consumption in Massachusetts cities in the years 1890, 1900, and 1910, obtained by courtesy of Mr. X. H. Goodnough, chief engineer, Massachusetts State Board of Health, is shown in Table 2.

TABLE 1.

GENERAL DATA RELATING TO THE WATER WORKS FROM WHICH INFORMATION WAS RECEIVED. FOR THE YEAR 1910.

City.	Population.		Taps.		Persons per Tap.	Water Consumption.					Minimum Rate.			Meter Rates per 100 c. f.		
	Total.	Served.	Number Live.	% Metered.		Mgd. Av.	Av. per Cap. Gpd.	Av. per Tap. Gpd.	Max. in % of Av. p. Cap. for 1 mo.	Max. in % of Av. p. Cap. for 1 dy.	% Taps paying only.	$ per Year.	Water Allowed for. Cubic Feet per Year.	Max. Cents.	Min. Cents.	First Step in Scale. Cubic Feet per Quarter.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1. Ansonia, Conn...	15 000	10 000	1 010	16%	14.9	1.20	80	1 188	...	...	...	$8	.....	18	5	10 000
2. Arlington, Mass.	11 187	10 500	2 065	62	5.4	0.93	84	453	...	...	...	13½	185*	15	11	.....
3. Baltimore, Md...	558 485	589 000	110 395	30	5.1	67.5	121	612	116	116	....	6	13 400	....	4.5	.....
4. Bangor, Me.....	24 803	.....	4 850	20	5.1	4.0	161	825	...	...	....	8	.....	55	....	.....
5. Bath, Me.....	9 396	.....	2 328	.....	4.0	1.73	185	746	109	119	....	20	8 000	25	8	.....
6. Calais, Me.....	7 500	.....	1 438	.....	5.2	0.70	±94	490	106	...	....	20	8 000	25	8	.....
7. Boston, Mass....	670 585	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8. Brewer, Me.....	5 600	6 500	1 325	.....	4.2	0.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9. Cambridge, Mass.	104 837	104 829	15 905	30	6.6	10.57	101	664	...	...	....	5	3 333	15	7.5	.....
10. Canandaigua, N. Y.....	7 300	7 500	1 546	110	4.7	0.86	100	520	127	154	....	8	3 300	6	6	.....
11. Claremont, N. H.	7 500	4 500	1 062	.....	7.0	.....	.....	.....	.....	.....	26	12	.....	15	7½	.....
12. Davenport, Ia...	43 000	.....	7 500	67	5.7	4.1	93	533	111	147	65	9	4 000	.....	.....	.....
13. Cleveland, Ohio.	560 663	618 000	83 011	98	6.8	65.7	.....	.....	.....	.....	62	2½	at 4¢	.....	.....	.....
14. Denison, Tex....	14 300	11 000	2 125	.....	6.7	0.6	56	376	...	192	38	6	.....	50	15	.....
15. Dover, N. H.....	13 247	12 500	1 901	.....	7.0	0.70	53	371	...	...	40	10	.....	22½	15	13 333
16. Fall River, Mass.	119 295	118 645	8 501	99	14.0	5.2	44	612	104	124	....	10	.....	.....	.....	.....
17. Fitchburg, Mass.	37 000	34 000	5 200	71	7.1	.....	.....	.....	.....	.....	8	5	.....	.....	.....	.....
18. Gardner, Mass...	14 699	13 965	1 732	7	8.5	0.64	46	369	...	...	.....	.....	.....	.....	.....	.....
19. Hartford, Conn..	98 915	121 644	12 621	98	7.8	8.05	66	647	...	...	.....	.....	.....	.....	.....	.....
20. Holyoke, Mass...	57 730	56 901	4 280	8	13.5	5.9	103	1 370	...	...	.....	7	.....	.....	.....	.....
21. Lawrence, Mass.	85 892	84 000	7 641	98	11.2	3.9	46	518	...	...	8	7	4 600	.....	.....	.....

22. Hyde Park, Mass.	15 506	.....	2 521	48	6.2	1.14	74	453	...	...	...	16	6 000	26	18.2	.....
23. Jamestown, N. Y.	34 057	32 000	6 504	51	5.2	3.17	99	488	...	...	20	8	4 000	20	6	1 000
24. Johnstown, Pa...	77 000	55 000	10 397	4	7.4	8.75	157	1 460	...	125	62	9	.....	27	5	10 650
25. Kingston, Mass..	2 500	2 000	475	.....	5.3	0.30	120	632	...	137	...	...	.....	...	...	.....
26. Lexington, Mass.	5 000	.....	838	57	6.0	0.35	69	427	...	...	42	12	5 333	...	...	.....
27. Lowell, Mass....	106 294	106 294	12 494	79	8.2	5.44	51	51	...	...	50	7	5 000	14	10	20 000
28. Manchester, N. H.....	75 000	73 000	6 700	77	11.2	3.8	52	570	...	...	...	10	8 000	12½	8	.....
29. Middleboro, Mass.....	8 230	.....	1 000	54	8.2	0.34	41	341	...	...	...	9	4 800	18¾	7½	.....
30. Milwaukee, Wis.	373 857	400 000	56 490	98	6.6	44.7	112	792	...	...	...	...	.....	...	...	.....
31. Nantucket, Mass.	3 000	2 500	1 160	0	2.6	0.18	72	155	...	...	...	...	.....	...	...	.....
32. Nashua, N. H....	27 000	25 000	3 759	25	9.8	2.53	94	670	105	159	...	16	10 700	15	3¾	10 000
33. New London, Conn.....	19 659	19 000	4 132	17	4.8	2.66	140	643	...	...	...	5	4 200	12	4½	7 500
34. Newport, R. I....	25 025	.....	5 522	3	4.5	3.93	157	713	...	...	...	...	.....	...	...	.....
35. New Rochelle, N. Y.....	38 288	37 500	5 810	99	6.6	3.20	85	551	...	...	...	12	5 600	15	...	.....
36. Pawtucket, R. I..	51 622	78 919	10 602	86	4.9	6.28	80	593	131	170	...	10	.....	22.4	4.5	1 336
37. Peoria, Ill.....	67 000	.....	9 170	4	7.3	8.0	119	870	119	154	...	3	2 000	15	4½	.....
38. Plymouth, Mass.	12 141	11 000	2 480	4	4.9	1.25	114	505	150	178	2	12	4 800	...	...	.....
39. Providence, R. I.	246 000	.....	27 818	89	8.8	15.6	63	550	109	137	±36	10	6 667	15	7½	100 000
40. Reading, Mass...	5 818	5 500	1 355	.....	4.3	0.21	37	151	...	...	36	6	1 067	...	...	.....
41. Saginaw, Mich...	51 510	.....	5 871	6	8.8	9.6	186	1 630	...	...	...	10	12 100	...	...	.....
42. Somerville, Mass.	77 236	80 000	12 357	53	6.2	5.9	74	478	...	...	...	6	5 000	12	8	1000000
43. Springfield, Mass.	88 926	87 500	12 545	61	7.1	10.6	121	844	...	...	37	8	3 600	22	5	900
44. Washington, D. C.....	331 000	.....	65 215	29	5.1	60.4	182	927	107	150	58	4½	7 500	3	...	.....
45. Watertown, Mass.....	12 875	12 800	2 042	100	6.3	0.88	68	431	...	...	33	10	4 000	25	5	.....
46. Wilkinsburg, Pa., *et als.*	86 755	86 755	11 788	.....	7.4	7.77	90	658	...	...	...	5	3 333	20	10	1000000
47. Wilmington, Del.	87 400	87 500	18 414	35	4.8	10.3	118	562	...	...	79	5	.....	7.5	36	2 000
48. Windsor, Conn. .	4 200	1 200	248	10	16.9	0.07	57	276	...	...	6	6	2 540	24	20	.....
49. Woonsocket, R. I.....	38 125	44 200	3 309	96	11.5	1.5	.....	.....	117	143	36	10	4 450	22.5	...	.....
50. Worcester, Mass.	145 986	156 362	.....	.....	.....	10.3	66	.....	...	...	...	4	2 667	15	7.5	61 000

*Gallons per day.

TABLE 2.—Water Consumption in Massachusetts Cities and Towns.

(By courtesy of X. H. Goodnough, Chief Engineer, Massachusetts State Board of Health.)

City or Town.	1890.			1900.			1910.		
	Population.	Average Daily Consumption.		Population.	Average Daily Consumption.		Population.	Average Daily Consumption.	
		Gallons.	Gal. per Capita.		Gallons.	Gal. per Capita.		Gallons.	Gal. per Capita.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Abington and Rockland	9 473	312 000	33	9 816	373 000	38	12 383	561 000	45
Andover	6 142	135 000	22	6 813	407 000	60	7 301	627 000	86
Beverly	10 821	743 000	69	13 884	1 003 000	72	18 650	1 702 000	91
Braintree	4 848	161 000	33	5 981	544 000	91	8 066	653 000	81
Bridgewater	7 160	85 000	12	8 831	223 000	25	11 051	245 000	22
Brookline	12 103	877 000	72	19 935	1 941 000	97	27 792	2 476 000	89
Cambridge	70 028	4 566 000	65	91 886	7 304 000	80	104 839	10 458 000	100
Danvers and Middleton	8 378	484 000	58	9 381	677 000	72	10 536	940 000	89
Dedham	7 123	223 000	31	7 457	586 000	79	9 284	1 202 000	129
Easton	4 493	93 000	21	4 837	114 000	24	5 139	124 000	24
Fall River	74 398	2 136 000	29	104 863	3 805 000	36	119 295	5 200 000	44
Framingham	9 239	204 000	22	11 302	433 000	38	12 948	627 000	48
Franklin	4 831	74 000	15	5 017	173 000	34	5 641	343 000	61
Lawrence	44 654	2 778 000	62	62 559	3 317 000	53	85 892	3 879 000	45
Lowell	77 696	5 374 000	69	94 969	7 893 000	83	106 294	5 443 000	51
Lynn and Saugus	59 400	2 657 000	45	73 597	4 680 000	64	97 383	7 027 000	72
Mansfield	3 432	145 000	42	4 006	133 000	33	5 183	387 000	75
Marlborough	8 202	157 000	19	7 582	506 000	67	14 579	541 000	37
Middleborough	6 065	129 000	21	6 885	233 000	34	8 214	341 000	42
Montague	6 296	283 000	45	7 123	446 000	63	8 014	531 000	66
Natick	9 118	264 000	29	9 488	378 000	40	9 866	566 000	57
New Bedford	40 733	4 066 000	100	62 442	6 318 000	101	96 652	7 864 000	81
Newburyport	13 947	426 000	31	14 478	617 000	43	14 949	1 020 000	68
Newton	24 379	985 000	40	33 587	2 086 000	62	39 806	2 505 000	63
Norwood	3 733	169 000	45	5 480	400 000	73	8 014	505 000	63

Peabody	10 158	827 000	81	11 523	1 036 000	90	15 721	2 645 000	168
Randolph and Holbrook	6 420	192 000	30	6 222	233 000	37	7 117	528 000	74
Salem	30 801	2 184 000	71	35 956	2 712 000	75	43 697	3 935 000	90
Taunton	25 448	807 000	32	31 036	1 645 000	53	34 259	2 150 000	63
Wakefield*	13 137	537 000	41	15 487	1 091 000	70	11 404	694 000	61
Waltham	18 707	626 000	33	23 481	2 118 000	90	27 834	2 443 000	88
Ware	7 329	160 000	22	8 263	286 000	35	8 774	401 000	46
Wellesley	3 600	255 000	71	5 072	239 000	47	5 413	331 000	61
Whitman	4 441	87 000	20	6 155	133 000	22	7 292	212 000	29
Woburn	13 499	777 000	58	14 254	1 117 000	78	15 308	2 134 000	139
Averages			46			60			82

*Wakefield and Stoneham combined 1890, 1900; Wakefield only, 1910.

TABLE 3.

PER CAPITA CONSUMPTION AND PER CENT. OF SERVICES METERED IN THE CITIES AND TOWNS SURROUNDING BOSTON, MASS., SUPPLIED FROM THE METROPOLITAN WATER WORKS, 1904–12 INCLUSIVE.

(By courtesy of Mr. Dexter Brackett.)

City or Town.	1904.		1905.		1906.		1907.		1908.		1909.		1910.		1911.		1912.	
	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.	Gals. per Cap. per Day.	Per Cent. of Services Metered.
Boston*	149	5.4	150	5.4	148	5.6	153	5.6	153	5.7	143	5.8	130	12.5	124	20.0	125	27.3
Chelsea	116	2.1	109	2.0	97	9.9	97	14.6	104	27.1	89	33.9	87	33.5	80	64.3	85	94.3
Everett	93	1.2	89	1.6	81	1.8	82	2.0	83	2.3	80	9.6	76	15.9	73	22.0	75	28.5
Malden	50	69.3	53	70.5	51	78.1	45	93.6	44	96.1	43	96.3	42	95.6	43	96.3	48	95.8
Medford	93	4.3	97	5.3	98	8.0	102	10.5	94	13.3	77	33.1	61	56.1	50	94.4	49	100.0
Melrose	109	3.1	112	3.2	109	3.3	117	3.9	89	30.9	62	100.0	64	100.0	63	100.0	69	100.0
Quincy	103	3.1	108	3.4	104	3.4	100	14.2	97	24.3	91	29.9	88	29.8	87	36.1	87	62.0
Somerville	92	5.9	89	11.5	89	18.5	90	24.6	89	29.6	83	36.6	80	42.8	74	47.8	79	53.2
Arlington	79	6.0	81	6.4	80	22.1	91	33.6	91	43.3	79	50.1	83	55.2	84	62.8	89	70.4
Belmont	58	100.0	61	100.0	59	100.0	68	100.0	71	100.0	58	100.0	59	100.0	71	100.0	71	100.0
Lexington†	72	1.2	74	1.8	81	2.2	77	2.1	77	11.0	76	33.1	78	46.4	77	56.8	75	69.7
Milton	45	100.0	45	100.0	48	100.0	46	100.0	44	100.0	40	100.0	39	100.0	39	100.0	41	100.0
Nahant‡	70	10.1	74	16.7	69	18.0	69	17.2	70	22.0	60	31.0	58	45.0	65	42.7	69	50.8
Revere§	75	1.9	77	2.3	77	4.0	81	4.7	78	5.6	72	9.7	71	18.4	75	26.0	75	34.9
Stoneham	88	1.6	81	2.0	68	1.7	91	1.9	92	2.3	82	12.8	91	29.7	78	43.3	78	55.4
Swampscott	88	0.0	88	0.0	78	0.0	73	37.8	76	68.3	56	89.2	59	97.2	59	99.1	61	100.0
Watertown	57	92.2	70	92.9	66	93.6	67	98.3	60	100.0	60	100.0	68	100.0	67	100.0	67	100.0
Winthrop	108	0.9	112	1.3	106	1.6	105	2.3	103	3.4	91	17.8	63	66.1	56	95.9	65	100.0
District	128	10.0	129	10.7	126	12.4	130	15.0	129	17.7	119	21.9	110	28.9	105	37.6	107	45.5

* Boston — Includes Hyde Park in 1912.

† Lexington — Allowance made for population not supplied, 1904–12 inclusive.

‡ Nahant and Swampscott — Allowance made for summer population, 1904–12 inclusive.

§ Revere — Includes small portion of Saugus, 1904–8 inclusive.

Year.....	1904	1905	1906	1907	1908	1909	1910	1911	1912
Lexington*....	64	66	73	69	69	68	70	69	68
Nahant*.....	136	147	135	130	129	108	101	121	120
Swampscott*..	104	103	91	85	87	64	66	67	68
District*.....	128	129	126	130	129	120	110	105	107

* No allowance made for summer population or population not supplied.

The population, per cent. of services metered, and the daily water consumption in gallons per capita, of the cities and towns now comprising the Metropolitan Water District, surrounding Boston, Mass., for the years 1904 to 1911 inclusive, are shown in Table 3, which has been kindly furnished by Mr. Dexter Brackett, chief engineer to the board.

Statistics relating to population, number of services, per cent. of services metered, and water consumption in million gallons per day and in gallons per day per tap or consumer, and per capita, in various other typical American cities, covering a period of one decade or more, are shown in Table 4.

TABLE 4.

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.
(Compiled by Metcalf & Eddy.)

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day. Per Capita.	Gallons per Day. Per Tap.
			Fall River, Mass.			
1874	44 000	0.51	672	0.78	11.52	760
1875	45 000	0.81	1 147	17	18.02	706
1876	43 000	1.06	1 660	35	24.60	639
1877	45 000	1.17	2 060	42	26.08	569
1878	48 000	1.20	2 324	50	25.09	517
1879	47 000	1.26	2 497	54	26.89	505
1880	48 626	1.36	2 685	59	28.35	507
1890	74 918	2.14	4 980	74	28.51	430
1900	107 623	3.80	6 943	94	35.35	547
1901	107 831	3.62	7 075	95	33.56	512
1902	108 728	4.37	7 282	95	40.15	600
1903	113 602	4.28	7 502	96	37.65	570
1904	113 645	4.09	7 667	96	36.00	534
1905	106 620	4.41	7 744	97	41.34	569
1906	107 911	4.48	7 845	98	41.49	571
1907	112 574	4.94	7 956	98	43.93	621
1908	114 242	4.97	8 108	98	43.48	613
1909	115 097	5.34	8 316	98	46.40	655
1910	119 295	5.20	8 501	99	43.59	611
1911	117 423	5.18	8 790	99	44.09	589

TABLE 4 (*Continued*).

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day. Per Capita.	Per Tap.
			Brockton, Mass.			
1900	40 063	.....	5 275		29.3	220.9
1901	41 610	.....	5 467	82.7	29.4	222.4
1902	43 159	.....	5 671	90	32.2	240
1903	44 704	.....	5 849	90.6	33.0	252.5
1904	46 248	.....	6 097	90	35.0	265.6
1905	47 792	.....	6 467	90.4	35.6	262.5
1906	57 000*	.....	6 820	91	34.3	286.9
1907	59 850*	.....	7 208	92	33.9	280
1908	62 400†	.....	7 504	100	35.9	298
1909	63 400†	.....	7 879	99	35.9	288.9
1910	66 000†	.....	8 179	99	36.2	292.7
1911	69 500‡	.....	8 426	100	39.0	322
			Lowell, Mass.			
1890	78 000	5.37	8 732	22	69	615
1895	86 500	6.92	9 686	33	80	714
1900	95 000	7.89	10 529	52	83	749
1901	97 000	7.06	10 799	61	73	654
1902	100 000	5.73	10 984	65	57	522
1903	102 000	5.26	11 109	65	51	474
1904	104 000	5.48	11 287	66	52	485
1905	94 889	....	11 451	69	58	478
1906	96 380	....	11 719	71	53	434
1907	96 330	....	11 968	74	57	462
1908	96 380	5.25	12 142	75	55	432
1909	105 000	5.24	12 307	77	50	425
1910	106 294	5.44	12 494	78	51	436
1911	106 294	5.27	12 719	80	50	415
			Lawrence, Mass.			
1880	39 151	1.86	3 224	6	46	577
1890	44 654	2.78	4 864	29	60	571
1900	62 559	3.33	6 079	76	50	548
1901	65 000	3.12	6 240	79	48	500
1902	68 500	3.43	6 375	84	50	537

* Includes Whitman.
† Includes Whitman and Hanson.
‡ Includes Whitman, Hanson, and West Bridgewater.

TABLE 4 (*Continued*).

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day. Per Capita.	Per Tap.
			Lawrence, Mass. (*Continued*).			
1903	66 500	2.83	6 483	86	43	437
1904	68 500	2.81	6 581	87	41	428
1905	69 300	3.00	6 680	88	43	449
1906	76 000	3.30	6 811	89	43	484
1907	78 000	3.51	6 970	89	45	504
1908	78 000	3.45	7 095	89	44	487
1909	82 000	3.57	7 416	90	43	481
1910	85 892	3.88	7 641	91	45	507
1911	87 000	3.94	7 802	92	46	505
			Worcester, Mass.			
1896	103 000	6.13	11 947	93	60	513
1897	106 500	6.08	12 330	93.4	57	493
1898	110 500	6.80	12 672	93.6	62	537
1899	114 500	7.63	13 008	94.2	67	587
1900	118 421	8.15	13 202	94.4	69	613
1901	120 500	9.01	13 607	94.3	75	662
1902	122 500	8.21	13 832	94.4	67	594
1903	124 500	9.69	14 129	94.5	78	686
1904	126 500	10.22	14 413	94.5	81	709
1905	128 135	9.64	14 760	96.0	75	652
1906	132 000	9.22	15 061	95.4	70	612
1907	147 084	9.43	15 369	96.2	70	614
1908	143 333	9.06	15 756	96.1	65	575
1909	146 417	8.87	16 263	95.8	62	545
1910	149 538	10.68	16 942	97.1	72	631
1911	155 162	10.34	17 652	97.2	68	586
			Providence, R. I.			
1880	108 923	3.55			33	
1890	141 294	6.74	14 861	62	48	
1900	187 297	10.13	21 566	83	54	470
1901	193 700	10.73	22 186	84	55	484
1902	198 400	11.56	22 758	84	58	508
1903	202 800	13.11	23 332	85	65	562
1904	207 900	13.86	23 881	86	67	581
1905	214 335	14.51	24 482	86	68	593
1906	219 800	15.05	25 094	87	68	601
1907	225 700	16.23	25 709	88	72	631

TABLE 4 (*Continued*).

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day. Per Capita.	Per Tap.
		Providence (*Continued*).				
1908	231 900	15.55	26 321	88	67	591
1909	237 200	15.16	27 068	89	64	561
1910	246 000	15.57	27 818	89	63	560
1911	254 100	....	28 491*	89*	..	...
		16.59	28 636	....	65	579
		Cleveland, Ohio.				
1880	156 000	10.18	10 013	4.43	65.3	1 016.6
1890	262 000	27.79	30 938	5.80	106.1	898.1
1900	397 200	67.09	53 473	5.87	168.9	1 254.6
1901	411 200†	69.65	55 130	6.42	169.4	1 263.2
1902	417 000†	69.96	56 816	19.88	167.8	1 231
1903	438 000†	62.01	58 852	42.81	141.6	1 054
1904	444 500†	61.57	60 627	50.09	138.5	1 061
1905	462 000†	60.42	64 137	69.70	130.8	918.7
1906	480 000†	59.05	69 128	82.04	123	875.6
1907	501 000†	58.88	72 225	88.60	117.5	815.2
1908	518 940†	52.05	74 490	93.61	100.3	710
1909	564 000†	52.81	76 777	97.31	93.6	687.86
1910	604 073†	61.50	80 686	97.67	101.8	762.57
1911	630 000†	65.69	83 301	98.26	104.3	788.06
		Chicago, Ill.				
1860	109 260	4.70	6 350	....	43	740
1870	306 605	21.77	35 318	....	71	616
1880	491 516	57.38	67 949	....	117	845
1890	1 208 669	152.37	155 096	....	126	980
1900	2 007 695	322.60	308 945	2.1	161	1 044
1901	1 786 226	342.82	315 954	....	192	1 087
1902	1 844 661	358.10	324 202	....	194	1 105
1903	1 903 096	376.02	331 506	....	196	1 136
1904	1 962 251	398.99	339 044	2.4	203	1 177
1905	2 060 000	410.85	345 174	....	200	1 190
1906	2 140 000	436.95	353 872	....	204	1 235
1907	2 250 000	454.62	362 623	....	204	1 252
1908	2 300 000	467.77	372 835	4.05	204	1 253
1909‡	2 163 000	480.91	382 500	3.89	222	1 257
1910‡	2 234 000	518.58	390 000	3.85	233	1 329

* To September 30, 1911.
† Includes suburbs supplied with water.
‡ These figures obtained from 35th Annual Report, Department of Public Works.

TABLE 4 (*Continued*).

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day. Per Capita.	Per Tap.
			Milwaukee, Wis.			
1885	158 509	16.06	10 990	5	101	1 461
1890	204 468	22.38	17 368	34	107	1 288
1895	249 283	25.29	29 797	53	101	849
1900	285 315	23.63	41 483	68	83	569
1901	300 000	24.07	43 386	72	80	555
1902	308 000	25.01	45 480	74	81	550
1903	325 000	26.27	47 481	77	80	553
1904	333 500	27.94	49 835	78	84	560
1905	342 500	29.65	52 115	80	86	569
1906	350 000	32.11	54 160	81	91	593
1907	360 000	33.73	56 518	82	93	596
1908	370 000	33.80	59 094	83	91	572
1909	380 000	36.11	61 589	83	95	586
1910	380 000	42.52	65 314	98*	111	785
1911	390 000	47.78	56 251	96	112	796
			St. Louis, Mo.			
		Year ending Dec. 31.	Year ending March 31.			
1890	451 700	35.2	38 183	8	78	920
1900	575 238	63.5	65 688	6	111	965
1901	586 400	65.8	67 243	7	112	980
1902	597 600	67.0	69 483	7	112	966
1903	608 800	68.1	72 005	6	112	946
1904	620 000	77.1	74 505	6	124	1 035
1905	631 200	72.1	77 951	6	114	925
1906	642 300	70.4	82 325	5	109	855
1907	653 500	69.2	87 734	5	106	789
1908	664 700	69.3	91 897	6	104	754
1909	675 900	73.7	97 031	6	109	759
1910	687 089	78.2	100 811	6	114	776
			Cincinnati, Ohio.			
1870	220 000	10.44	18 629	0.7	48	561
1875	240 000	14.31	21 336	0.6	60	671
1880	260 000	19.48	23 627	2.3	75	825
1885	310 000	19.80	28 522	4.1	64	694
1890	296 908	33.99	35 439	4.1	114.50	959

* Based on services actually in use — previously based on total number of services.

TABLE 4 (*Continued*).

STATISTICS RELATING TO THE CONSUMPTION OF WATER IN VARIOUS CITIES.

Cincinnati (*Continued*).

Year.	Population.	Consumption, Mgd.	Services.	Per Cent. of Services Metered.	Gallons per Day.	
					Per Capita.	Per Tap.
1891	298 723	42.12	36 754	4.2	140.99	1 146
1892	300 550	38.68	37 981	4.4	128.68	1 019
1893	302 389	39.15	39 452	4.4	129.46	993
1894	304 240	41.36	40 988	4.5	135.93	1 009
1895	306 103	47.14	42 272	4.9	154.01	1 115
1896	318 028	44.61	44 774	5.7	140.27	997
1897	319 978	43.93	45 674	5.2	137.30	963
1898	321 940	38.35	46 380	5.5	119.10	828
1899	323 915	39.57	35 942	7.6	122.17	1 100
1900	325 902	38.06	36 215	8.2	116.77	1 050
1901	327 903	40.80	36 829	8.8	124 40	1 108
1902	329 982	43.03	37 302	9.7	130.31	1 153
1903	332 139	45.68	37 942	10.0	137.52	1 204
1904	340 900	48.54	39 308	11.2	142.37	1 234
1905	343 254	44.33	39 308	12.2	129.15	1 127
1906	345 727	50.90	41 037	12.4	147.23	1 240
1907	348 319	45.89	42 765	15.3	131.76	1 073
1908	351 030	41.72	43 922	21.0	118.85	950
1909	355 000	42.42	45 593	27.0	119.50	931
1910	363 591	46.48	47 276	32.8	127.83	984
1911	383 700	48.06	51 366	47.9	125.28	742

Incidentally, the difficulty of getting reliable water consumption statistics is illustrated by a letter received from the water commissioner of one of these cities, in response to inquiry as to the cause for the difference between the published per tap figures and the figures obtained by applying the data contained in the report upon these works. The Commissioner writes, —

"I have made some inquiries of the registrar's department, where they make up the figures of gallons per tap, and find they use the registration of the meters down town, instead of the amount passing through the Venturi meters at the reservoirs. This, of course, makes the figures of no value. I imagine they will change their system and make it accord with the Venturi meter readings."

Error is often introduced, too, by difference in usage, some departments basing their consumption statistics upon total popula-

tion, others upon population served, some upon services, others upon taps, still others upon the number of consumers; and the three latter classes are further subdivided by those works which make use of the total number of services, taps, or consumers, while other works make use of the live services, taps, or consumers. The term "consumer," as applied to taps or services, has been used as practically synonymous with the "family" in Wisconsin. Thus there may be several consumers (or families living independently, with separate kitchen) supplied through one tap, and through one or more meters. In the East, however, it is used to signify the number of persons served.

Table 5, with accompanying diagram, Plate VIII, is reprinted by courtesy of Mr. E. S. Cole, from data collected by him.

Statistics relating to maximum, minimum, and average daily consumption in American cities, based upon the United States Census Bureau Report of 1907, upon "Statistics of Cities," are shown in Table 6.

TABLE 6.

CONSUMPTION OF WATER IN AMERICAN CITIES.

Computed from data in "Statistics of Cities, 1907," United States Census Bureau.

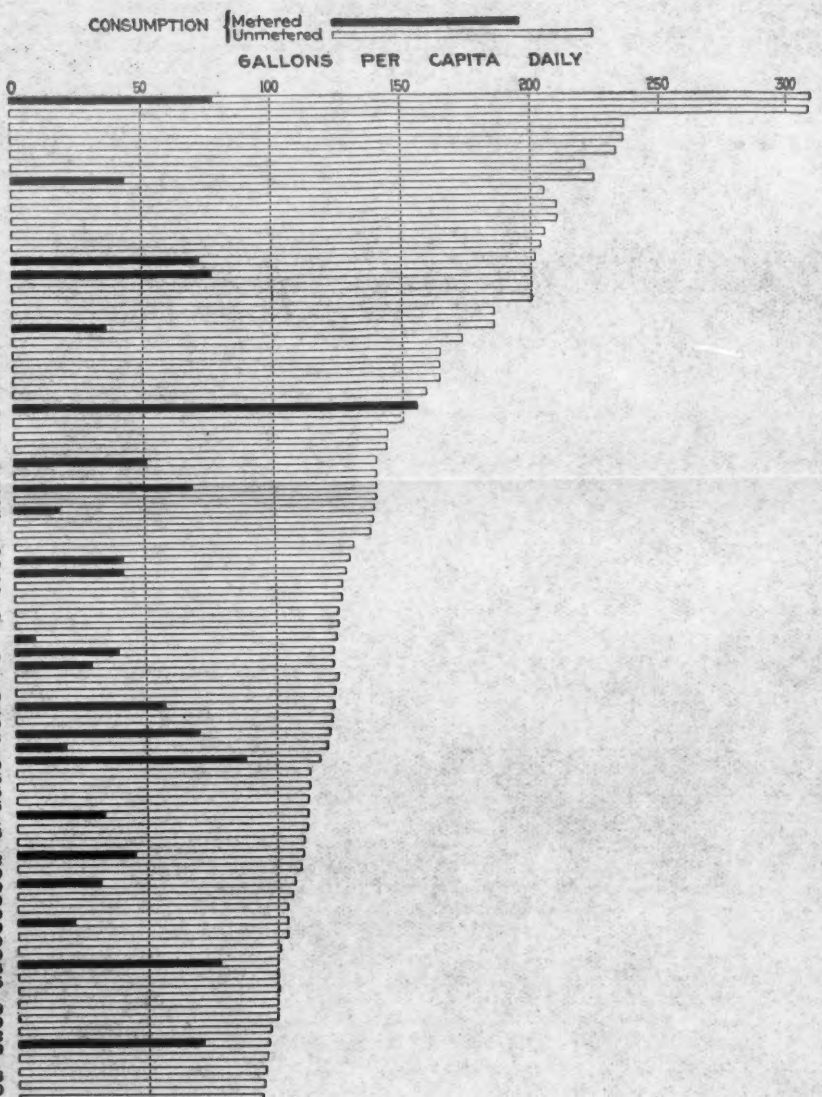
(Note that Average Consumption has been computed by averaging the per capita figures for the several cities.)

Group.	Population.	Number of Cities.	Approximate Average Population.	Daily Consumption of Water. Gal. per Day per Capita. Maximum.	Minimum.	Average.
I	Over 300 000	13	910 000	344	76	164
II	100 000–300 000	22	161 000	230	51	111
III	50 000–100 000	34	71 000	301	40	116
IV	30 000–50 000	44	40 000	398	26	117
Total		113				
Averages			180 000			121
Extremes				398	26	

Statistics relating to 37 English cities, 41 French cities, and 38 German cities, as reported by Debauve and Imbeaux in "Distributions d'Eau," Vol. 2, 1905, converted into American units by Mr. Emil Kuichling, of New York, are shown in Tables 7, 8, and 9 following.

TABLE 5—WATER CONSUMPTION OF CITIES

City	Pop.	Date	Per cent. taps metered
Buffalo, N. Y.	423,700	'11	4.0
Salt Lake City	57,800	'06	2.0
Waco, Tex.	25,000	'12	..
St. John, N. B.	46,000	'08	3.2
Kingston, N. Y.	25,900	'08	..
Albany, N. Y.	100,200	'10	23.8
Chicago, Ill.	2,185,200	'11	6.0
Erie, Pa.	66,500	'10	2.5
Pittsburgh, Pa.	363,000	'06	10.0
Bridgeport, Conn.	82,000	'06	5.0
Philadelphia, Pa.	1,599,000	'10	..
Port Huron, Mich.	34,700	'10	..
Springfield, Ill.	25,000	'09	17.8
Grand Rapids, Mich.	81,000	'10	42.0
Mobile, Ala.	65,000	'12	10.0
Charleston, S. C.	25,000	'12	3.7
Peabody, Mass.	12,600	'09	..
Auburn, N. Y.	34,600	'11	5.3
Lafayette, Ind.	20,000	'10	9.0
Camden, N. J.	80,000	'08	..
Savannah, Ga.	65,000	'12	2.0
Augusta, Ga.	45,000	'12	5.0
Jersey City, N. J.	267,700	'10	9.0
Columbia, S. C.	27,000	'12	100.0
Jackson, Miss.	21,600	'12	15.0
Greensboro, N. C.	9,000	'12	6.0
Bangor, Me.	24,800	'07–'08	..
New London, Conn.	19,300	'10	15.0
Pawtucket, R. I.	50,000	'08	83.6
Lancaster, Pa.	45,000	'06	30.0
Binghamton, N. Y.	48,400	'10	29.0
Woburn, Mass.	15,200	'10	2.8
Atlantic City, N. J.	37,500	'06	78.4
Montreal, Can.	312,300	'09	..
San Antonio, Tex.	100,000	'12	16.0
Boston, Mass.	674,400	'10	20.0
Cincinnati, Ohio.	360,000	'10	32.8
Perth Amboy, N. J.	40,000	'10	29.0
New Brunswick, N. J.	23,300	'10	..
Meridian, Miss.	20,000	'12	14.0
Evansville, Ind.	69,600	'10	..
North Adams, Mass.	23,000	'09	..
Reading, Pa.	98,500	'08–'09	11.9
Baltimore, Md.	575,000	'09	..
Schenectady, N. Y.	72,800	'09	..
Nashville, Tenn.	100,000	'12	74.0
Springfield, Mass.	87,500	'10	60.8
Indianapolis, Ind.	150,000	'09	5.0
Wilmington, Del.	87,500	'10	34.3
Haverhill, Mass.	42,000	'10	17.1
Harrisburg, Pa.	64,100	'11	81.0
Kansas City, Mo.	250,000	'10–'11	44.5
Milwaukee, Wis.	385,000	'11	81.5
St. Louis, Mo.	687,000	'10	6.6
Louisville, Ky.	201,600	'10	8.1
Met. Water Board	1,022,200	'10	37.6
Pittsfield, Mass.	32,000	'10	..
Newark, N. J.	331,000	'09	49.2
Bayonne, N. J.	55,500	'10	99.0
Holyoke, Mass.	56,900	'10	9.0
Cambridge, Mass.	100,000	'10	38.0
Knoxville, Tenn.	60,000	'12	42.0
Plymouth, Mass.	12,100	'10	94.0
Richmond, Va.	127,600	'12	69.0
Peoria, Ill.	73,000	'12	36.0
Cleveland, Ohio.	516,000	'08	93.6
Macon, Ga.	50,000	'12	26.5
New York City	4,910,000	'11	..
Austin, Texas	35,000	'12	100.0
Atlanta, Ga.	150,000	'12	100.0
Toronto, Ont.	360,000	'10	4.2
Yonkers, N. Y.	77,500	'09	100.0
Memphis, Tenn.	135,000	'12	..
Holland, Mich.	10,000	'10	96.6
Andover, Mass.	7,000	'07	80.0



Memphis, Tenn.	135,000	'12	..
Holland, Mich.	10,000	'10	96.6
Andover, Mass.	7,000	'07	80.0
Dallas, Tex.	93,000	'12	..
East Orange, N. J.	35,700	'10	18.1
Beverly, Mass.	18,600	'10	4.1
Stoneham, Mass.	7,100	'10	43.3
Poughkeepsie, N. Y.	27,900	'08	89.5
Syracuse, N. Y.	137,200	'08	87.6
Jamestown, N. Y.	31,200	'10	51.0
Salem, Mass.	43,600	'10	89.7
Brookline, Mass.	27,700	'10	..
Waltham, Mass.	27,700	'10	12.0
South Bend, Ind.	53,600	'10	17.8
Quincy, Mass.	32,800	'10	36.0
Utica, N. Y.	74,400	'10	100.0
Duluth, Minn.	78,400	'10	51.5
Chelsea, Mass.	32,500	'10	64.3
Hartford, Conn.	85,000	'09	98.8
Bridgeton, N. J.	14,200	'10	..
New Bedford, Mass.	92,000	'10	47.8
Arlington, Mass.	11,200	'10	62.8
Spartanburg, S. C.	12,000	'12	37.0
Marion, Ind.	19,300	'10	17.3
Rockford, Ill.	45,500	'10	49.2
Fitchburg, Mass.	37,000	'10	70.2
Columbus, Ohio.	200,000	'09	80.0
New Orleans, La.	200,000	'12	100.0
Somerville, Mass.	77,600	'10	47.8
Lexington, Mass.	4,400	'10	56.8
Everett, Mass.	33,700	'10	22.0
Washington, D. C.	331,000	'10	25.0
Dayton, Ohio.	116,500	'09	74.6
Providence, R. I.	224,300	'11	89.2
Worcester, Mass.	149,500	'10	65.7
Lynn, Mass.	85,300	'08	40.0
Revere, Mass.	18,500	'10	26.0
Manistee, Mich.	14,000	'09-'10	9.0
Galveston, Tex.	40,000	'12	99.0
Hamilton, Ohio.	35,200	'09	60.0
Taunton, Mass.	32,500	'11	53.0
Watertown, Mass.	12,900	'10	100.0
Battle Creek, Mich.	27,000	'11	96.0
Toledo, Ohio.	195,000	'11	86.0
Jacksonville, Fla.	58,000	'09	70.0
Melrose, Mass.	15,700	'10	100.0
Framingham, Mass.	10,200	'08	77.0
Chicopee, Mass.	25,400	'10	..
Winthrop, Mass.	10,200	'10	95.9
Fort Worth, Tex.	80,000	'12	100.0
Newton, Mass.	39,600	'10	88.6
Fort Wayne, Ind.	63,800	'08	34.5
St. Paul, Minn.	214,700	'10	51.0
Medford, Mass.	23,300	'10	94.4
Covington, Ky.	53,200	'10	100.0
Minneapolis, Minn.	315,000,	'09	78.8
Tampa, Fla.	50,000	'12	25.0
Newport, Ky.	35,000	'10	31.0
Topeka, Can.	43,600	'10	68.0
Belmont, Mass.	5,600	'10	100.0
Swampscott, Mass.	6,900	'10	99.1
Westerly, R. I.	12,000	'09	..
Nahant, Mass.	2,100	'10	42.7
Norwood, Mass.	....	'05	..
Natick, Mass.	9,600	'09	65.0
Gardner, Mass.	11,300	'09	7.0
Madison, Wis.	26,900	'09	99.0
Gloucester, Mass.	23,000	'09	5.0
Charlotte, N. C.	20,000	'12	100.0
Lowell, Mass.	96,300	'08	75.3
Aurora, Ill.	33,000	'09	..
Houston, Tex.	105,000	'12	89.0
Attleboro, Mass.	17,500	'10	100.0
Kalamazoo, Mich.	39,400	'10	96.6
Ware, Mass.	9,000	'09	93.0
Fall River, Mass.	114,300	'09	98.8
Wellesley, Mass.	7,000	'09	100.0
Franklin, N. H.	4,800	'08	100.0
Lawrence, Mass.	82,000	'09	90.0
Marlborough, Mass.	13,800	'09	65.
Sioux City, Iowa.	25,200	'09	100.0
Malden, Mass.	44,700	'10	96.3
Quincy, Ill.	36,500	'10	58.0
Dover, N. H.	13,000	'11	73.0
Methuen, Mass.	12,000	'11	75.2
Lexington, Ky.	45,000	'10	56.8
Danville, Va.	19,000	'08	95.2
Milton, Mass.	7,900	'10	100.0
Middleboro, Mass.	7,000	'05	..
Concord, N. H.	21,500	'10	57.2
Brockton, Mass.	66,000	'10	99.4
Woonsocket, R. I.	42,700	'10	57.0
Reading, Mass.	5,700	'09	97.0
Auburn, Me.	15,000	'10-'11	..
Winchendon, Mass.	7,200	'09	85.0

(From *Engineering News*, Aug. 22, 1912.)

PLATE VIII.
N. E. W. W. ASSOCIATION.
VOL. XXVI.
COMMITTEE ON
WATER CONSUMPTION.

TABLE 7.

POPULATION, AVERAGE WATER CONSUMPTION AND PRICE PER 1 000 U. S. GALLONS IN 37 ENGLISH CITIES, IN YEAR 1902.

(From Debauve and Imbeaux, " Distributions d'Eau," Vol. 2, 1905.)

City.	Population, Census 1901.	Average Consumption per Head and Day, U. S. Gallons.	Price per 1 000 U. S. Gal. Cents.	
			From	To
Aberdeen	155 000	54.0	11.8	3.4
Ashton	140 000	24.0	33.8	16.9
Belfast	360 000	39.6	16.9	9.3
Birkenhead*	104 920	40.8	19.8	14.5
Birmingham*	775 502	33.6	32.1	10.1
Blackburn*	130 000	30.0	10.1	3.4
Bolton*	237 159	32.4	15.2	10.1
Bournemouth*	85 920	27.6	40.6	20.3
Bradford*	450 000	54.0	15.2	11.8
Briston*	353 374	26.4	30.4	10.1
Cardiff*	190 000	30.0	30.4	10.1
Darlington	46 000	25.2	20.3	6.8
Derby*	129 500	26.4	20.3	7.6
Dublin*	333 300	43.2	10.1	6.8
Dundee*	202 000	60.0	...	10.1
Edinburgh*	435 500	48.6	...	10.1
Glasgow*	1 075 735	67.2	...	6.8
Halifax*	224 933	18.0	13.5	10.1
Leeds*	430 000	42.6	...	10.1
Liverpool*	850 000	37.7	15.2	10.1
London	6 304 653	40.8	20.3	10.1
Manchester*	1 082 000	34.8	40.6	8.5
Newcastle*	485 000	45.5	13.7	8.5
Northampton*	120 000	18.8	...	30.4
Nottingham*	301 000	24.0	16.9	10.1
Oldham*	223 000	27.0	40.6	10.1
Paisley*	101 000	83.2	...	7.6
Plymouth*	132 326	55.2	...	3.4
Portsmouth*	200 000	48.7	30.4	13.5
Rochdale	100 000	22.8	20.3	10.1
Sheffield*	429 552	32.4	16.9	10.1
S. Essex*	146 000	24.0	16.9	13.5
Stockport*	135 000	27.0	...	...
Stockton*	220 000	62.4	30.4	5.1
Swansea*	110 000	34.8	25.4	10.1
Wakefield*	138 000	21.6	...	...
Wolverhampton*	136 000	26.4	27.0	10.1
Averages of 37		37.6	20.4	10.3
			Extreme Range =40.6¢ to 3.4¢.	

* Indicates that adjacent communities are also supplied.

TABLE 8.

POPULATION, AVERAGE WATER CONSUMPTION AND PRICE PER 1 000 U. S. GALLONS IN 41 FRENCH CITIES, IN YEAR 1902.
(From Debauve and Imbeaux, " Distributions d'Eau," Vol. 2, 1905.)

City.	Population, Census 1901.	Average Consumption per Head and Day, U. S. Gal.	Number of Taps.	Price per 1 000 Gal. Cents.	Average Number Persons per Tap.
Albi	22 571	58.2	1 275	12.6	17.7
Amiens	90 758	24.1	6 600	21.9	13.8
Angers	82 398	37.3	5 000	13.1	16.5
Angoulême	37 650	35.4	1 390	10.2	27.1
Auxerre	18 901	76.2	1 200	17.1	15.8
Avignon	46 786	36.5	2 203	8.0	21.2
Bar-le-Duc	17 693	31.2	840	20.4	21.1
Besançon	55 362	131.0	1 707	13.9	32.4
Bordeaux	256 638	46.3	22 129	16.1	11.6
Boulogne	49 940	38.3	1 698	12.0	29.4
Bourges	46 551	28.0	2 300	12.0	20.3
Brest	84 184	7.1	2 350	45.0	35.8
Caen	44 794	52.0	1 379	17.5	32.4
Calais	59 743	74.5	6 226	14.6–43.8	9.6
Chartres	23 431	26.7	1 300	14.6	18.0
Chateauroux	24 957	24.6	1 000	18.3	25.0
Cherbourg	42 938	32.0	2 011	24.1	21.4
Dijon	71 326	50.2	2 000	18.3	35.7
Épinal	28 080	69.0	1 030	11.0	27.2
Grenoble	68 615	273.0	7 031	4.0	9.7
La Rochelle	31 559	41.2	2 650	18.3	11.9
Le Havre	130 196	31.4	7 141	28.0	18.2
Le Mans	63 227	47.3	3 442	11.0	18.4
Lille	210 696	67.7	10 598	20.4	19.9
Limoges	84 121	29.9	2 450	18.0	34.4
Lyon	459 099	49.7	51 141	16.1	9.0
Mâcon	18 928	50.0	3 100	21.9	6.1
Montpellier	75 950	87.7	2 850	21.9	26.7
Nevers	27 673	21.1	1 200	21.9	23.1
Nismes	80 605	47.3	2 395	14.6	33.6
Orleans	67 311	30.6	5 068	18.7	13.3
Paris (2 systems)	2 714 068	97.8	93 035	25.6	29.2
Poitiers	39 886	24.3	2 330	13.7	17.2
Reims	108 385	52.3	5 000	19.7	21.7
Rochefort	36 458	24.3	1 626	18.1	22.4
Rennes	74 676	51.8	2 192	20.0	34.0
St. Étienne	146 559	54.7	6 500	20.0	22.6
Toulon	101 602	40.2	3 633	12.0	28.0
Toulouse	149 841	70.0	5 000	18.3	30.0
Tours	64 695	54.2	4 350	8.8	14.9
Versailles	54 983	66.8	2 975	20.0	18.5
Averages of 41		53.5		*	

* Maximum = 45.0¢.
Minimum = 4.0¢.
Mean = 17.7¢.

TABLE 9.

POPULATION, AVERAGE CONSUMPTION, AND PRICE PER 1 000 U. S. GALLONS IN 38 GERMAN CITIES, IN YEAR 1900.
(From Debauve and Imbeaux, " Distributions d'Eau," Vol. 2, 1905.)

City.	Population.	Average Consumption per Head and Day, U. S. Gal.	Price per 1 000 Gal. Cents.		Per Cent. Water Not Accounted for.
			From	To	
Aachen	135 235	20.6	13.5	9.0	26.3
Augsburg	9 109	55.0	27.0	2.7	5.1
Barmen	141 947	51.0	10.8	6.3	10.0
Berlin	1 884 151	20.6		13.5	8.6
Brunswick	128 177	20.1		9.0	8.3
Bremen	163 418	25.9	13.5	10.8	6.7
Breslau	422 738	22.0	13.5	9.0	14.2
Chemnitz	209 584	11.4	40.5	9.0	...
Cottbus	39 327	12.4	16.2	10.8	...
Danzig	140 539	22.0	36.0	18.0	16.0
Darmstadt	72 019	24.8	19.8	15.3	15.4
Dortmund	142 418	66.0	9.0	4.5	4.5
Dresden	395 349	27.8	10.8	9.7	0.4
Düsseldorf	213 767	28.3	10.8	1.8	5.0
Duisburg	92 929	35.7	9.0	5.0	...
Essen	118 863	38.0	9.0	7.2	10.2
Frankfurt a/M	288 489	62.1	22.5	13.5	8.0
Fürth	54 142	15.9		10.8	14.4
Göttingen	30 234	13.2	20.7	16.2	28.3
Guben	33 096	5.8	18.0	10.8	...
Hamburg	705 738	46.1		9.0	0.2
Hannover	235 666	24.3	18.0	15.3	10.7
Kiel	107 938	16.4		20.7	18.9
Köln	372 229	32.2	13.5	4.5	22.1
Leipzig	455 089	18.0	19.8	14.4	31.3
Mannheim	140 384	22.5	18.0	5.4	15.0
Metz	58 421	34.6	19.8	10.0	39.6
München	499 959	53.6		4.5	0.1
Münster	63 776	21.7	12.6	6.3	10.1
Nürnberg	261 022	19.6	18.0	9.0	12.6
Plauen	73 891	7.8		18.0	...
Solingen	45 249	14.5	19.8	9.9	15.4
Spandau	65 014	11.6	13.5		3.3
Stralsund	31 083	20.6	18.0	10.8	23.7
Strassburg	150 268	27.8		13.5	9.8
Stuttgart	176 318	28.0	27.0	1.8	11.9
Würzburg	75 497	60.8	6.3	4.8	17.9
Zwickau	55 825	17.7	36.0	12.6	4.0
Average of 38		27.8		*	

* Extreme range = 40.5¢ to 1.8¢.
Means = 16.8¢ to 9.9¢.

TABLE 10.

WATER CONSUMPTION STATISTICS FROM GERMAN CITIES AND OTHER EUROPEAN CITIES OR DISTRICTS OF MORE THAN 100 000 POPULATION, ARRANGED IN ORDER OF POPULATION.

(From Report of Committee on Water-Works Management, to the *Deutscher Verein von Gas und Wasserfachmännern, 1910.*)

Number.	Place and District Supplied.*	Business Year.	Population Supplied.	Consumers or Taps.	Number of Hydrants.		Delivery in U. S. Gallons per Capita, Based upon Number of Inhabitants.		
					Above Ground.	Below Ground.	Maximum.	Minimum.	Average.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	Berlin	1908–1909	2 183 531	29 707	7 094	....	32	15	22
2	Hamburg	1908–1909	864 000	24 329	5 244	302	50	30	39
3	Gelsenkirchen	1908	800 000	.....	3 043		86	40	68
4	Charlottenburg	Oct. 1, '08–Sept. 30, '09	720 292	17 273	7 646		39	16	24
5	Leipzig	1908	564 300	10 359	3 203	....	26	11	18
6	München	1908	561 000	16 270	3 611	215	100	57	63
7	Dresden	1908	532 000	16 442	4 054	....	40	17	26
8	Breslau	Apr. 1, '08–Mar. 31, '09	496 896	10 106	3 579	18	34	15	22
9	Cöln	1908–1909	441 700	26 564	4 716		47	27	37
10	Frankfurt	1908–1909	380 315	20 086	1 975	480	51	26	38
11	Frankfurt†	1908–1909	356 724	2 491	1 227	235	13	1.3	4.8
12	Hannover	1908–1909	358 880	12 101	1 942	....	25	14	18
13	Düsseldorf	1908–1909	343 528	14 254	2 497	168	51	22	35
14	Dortmund	1908–1909	331 224	10 490	1 309	18	90	43	67
15	Nürnberg	1908	313 880	12 680	4 059	1 265	31	12	22
16	Mülheim a. d. Ruhr	1908	300 000	7 061	1 122	....	102	45	74
17	Essen	1908–1909	278 707	13 317	1 828		56	28	44
18	Stuttgart	1908–1909	269 709	13 639	3 724	19	43	12	25
19	Chemnitz	1908	269 517	7 722	1 594	30	22	7	13

20	Charlottenburg	1908–1909	269 479	4 586	1 670		39	16	24
21	Magdeburg	1908	247 521	6 897	2 621	....	25	12	18
22	Bremen	1908–1909	237 000	31 698	2 033	464	66	31	48
23	Königsberg	1908–1909	236 292	6 768	687	176	28	14	20
24	Stettin	1908–1909	233 000	4 573	1 981	86	26	10	17
25	Elberfeld	1908–1909	202 000	9 059	1 472		44	16	35
26	Altona-Blankenese	1908–1909	190 837	10 243	1 024	54	47	27	38
27	Bochum	1908–1909	186 653	6 888	1 044	3	88	39	73
28	Halle	1908	183 996	7 712	1 379	187	31	12	21
29	Kiel	1908	181 888	7 450	1 257	17	25	11	18
30	Mannheim	1908–1909	179 000	9 300	1 475	5	38	16	26
31	Strassburg	1908	176 000	7 488	3 378	....	52	24	33
32	Barmen	1908–1909	164 600	8 610	917	131	54	27	42
33	Danzig	1908–1909	158 235	6 697	1 004	13	..	..	24
34	Cassel	1908	156 200	5 803	1 299	149	29	16	23
35	Aachen	1908–1909	151 000	8 841	1 042	....	31	17	26
36	Posen	1908–1909	150 000	2 870	....	885	33	13	22
37	Braunschweig	1908–1909	144 000	7 242	880	197	30	14	21
38	Basel	1908–1909	137 500	10 117	2 344	....	34	13	26
39	Mülheim a. d. Rhine	1908–1909	137 448	7 613	973	....	37	16	28
40	Duisburg	1908–1909	135 116	8 774	1 299	....	49	21	39
41	Crefeld	1908–1909	127 377	9 053	1 295	....	49	14	35
42	Karlsruhe	1908	123 300	5 149	1 059	....	52	18	31
43	Mülhausen	1908–1909	118 000	7 206	1 322	....	49	14	31
44	Weisbaden	1908–1909	113 000	5 915	1 469	26	42	20	29
45	Meissen	1908–1909	112 600	5 569	1 411	75	31	7	16
46	Plauen	1908	111 920	5 671	778	4	17	10	11
47	Witten	1908–1909	104 016	1 911	290	....	61	32	52
48	Lichtenberg	1908	102 307	933	....	....	26‡	9‡	13‡
	Averages						44.1	19.6	30.8

* City names only refer to the district supplied, which in many cases had many times the population of the city proper.
† River water without filtration for industrial purposes. ‡ Only Lichtenberg proper.

TABLE 10 (*Continued*).

WATER CONSUMPTION STATISTICS FROM GERMAN CITIES AND OTHER EUROPEAN CITIES OR DISTRICTS OF MORE THAN 100 000 POPULATION, ARRANGED IN ORDER OF POPULATION.

Number.	Place.	Business Year.	Population Supplied.	Consumers or Taps.	Number of Hydrants.		Delivery in U. S. Gallons per Capita, Based upon Number of Inhabitants.		
					Above Ground.	Below Ground.	Maximum.	Minimum.	Average.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
49	Vienna, Austria....	1908	1 999 630	33 937	1 913	1 986	18	8	14
50	Amsterdam, Holland.....	1908	565 632	43 469	5 139	117	21 11*	11 4*	15 8*
51	Copenhagen, Denmark.....	1908–1909	447 000	....	2 100	500	37	17	28
52	Stockholm, Sweden	1908	338 521	8 041	1 790	....	36	15	26
53	Riga, Russia.....	1909–1910	270 000	4 095	1 065	....	31	13	20
54	Zurich, Switzerland	1908	175 000	10 359	3 203	....	..	..	..
55	Krakau, Austria...	1908	147 701	2 235	544	99	145	66	111
56	Genf, Switzerland..	1908	125 000	7 197	1 030	....	..	..	225†
57	Brunn, Austria....	1908–1909	119 908	3 042	968	....	45	18	31

* These figures refer to river water for public and industrial purposes.

† Not typical, as a very large number of water motors are used.

It will be noted that the average daily consumption, in United States gallons per capita, shown in Tables 6 to 8, is as follows:

Country.	Number of Cities.	Average Daily Consumption U. S. Gal. per Capita.
United States	113	121
England	37	38
France	41	54
Germany	38	28*

Later information concerning water consumption statistics in German cities, and of a few other European cities or districts, is contained in an admirable report of the *Deutscher Verein von Gas und Wasserfachmännern*, on "*XXI Statistische Zusammenstellung der Betriebs-Ergebnisse von Wasserwerken*," published in 1910, which has been abstracted for cities or districts having a population of over 100 000, and converted into American units by Metcalf & Eddy, in Table 10. From this it will be noted that the average daily consumption reported is approximately 31 U. S. gallons per capita in the 48 German cities referred to.

One is immediately struck in studying such statistics by the tremendous variation in the daily per capita water consumption.

To what is this variation due? Your committee is of the opinion that it is due chiefly to the difference in the use of water for industrial purposes, and in less measure to the method of selling the water, whether by flat rates or meters; to the difference in character of population and life of the community; to public uses; and to the waste or losses from the pipe system and fixtures. Climatic conditions also have some influence upon consumption. Thus in the high, dry, semi-arid regions of the middle West it is reasonable to anticipate greater use of water for the sprinkling of lawns and for watering streets, which will increase substantially the per capita daily consumption. Illustrative examples of these several influences are submitted in the following pages.

Classification of Water Consumption.

Water consumption may be classed broadly under the following heads:

* See also Table 10.

1. Domestic uses.
2. Industrial uses.
3. Public uses.
4. Leakage and Unaccounted-for Water.

The variation in the domestic use of water by different classes of buildings or consumers is interestingly shown in Table 11, containing the replies received to the circulars sent out. The classification indicates an average water consumption of 64 gallons per capita per day in apartment houses, 55 in first-class dwellings, 34 in middle-class dwellings, and 15 in lowest-class dwellings.

The classification referred to was still more closely defined in two cases, as follows: —

By Mr. C. M. Saville, chief engineer, Board of Water Commissioners, Hartford, Conn., —

"APARTMENT HOUSES A. These are strictly first-class flats, the best kind in the city, similar to the Charlesgate in Boston, being, perhaps, 5-room suites renting from $35 to $50 a month, with bath, hot and cold water, janitor service, etc., and each building having from 16 to 24 suites.

"APARTMENT HOUSES B. These consist of the better class of 6- and 8-room tenement buildings, renting, perhaps, from $15 to $20 a month, having about 5 rooms and a bath, but with no heat or janitor service.

"FIRST-CLASS RESIDENCE DISTRICT. Class A houses include the very best dwellings in the city, the estates being worth, perhaps, from $50 000 to $60 000, 15 to 20 rooms, and all the modern plumbing that would go with this class of building, similar to the largest and finest estates in Brookline, the Newtons, and Milton.

"Class B includes dwellings worth from $12 000 to $18 000, fully plumbed 12-room houses, with baths, toilets, etc., similar to the single dwellings that may be found on West Newton Hill, Chestnut Hill, and in Brookline on the north side of Beacon Street, west of Coolidge Corner."

TABLE 11.

WATER CONSUMPTION PER CAPITA IN HOUSES OF DIFFERENT CLASSES, IN COMMUNITIES FROM WHICH REPLIES WERE RECEIVED. YEAR 1910 OR 1911.

City.	APARTMENT HOUSES.			FIRST-CLASS DWELLINGS.			MIDDLE-CLASS DWELLINGS.			LOWEST-CLASS DWELLINGS.		
	No. of Houses.	No. of Persons.	Gal. per Day per Capita.	No. of Houses.	No. of Persons.	Gal. per Day per Capita.	No. of Houses.	No. of Persons.	Gals. per Day per Capita.	No. of Houses.	No. of Persons.	Gal. per Day per Capita.
Baltimore, Md.	...	...	...	...	...	...	20	126	54	25	84	16
Boston, Mass.	50	2 164	37	40	400	60	50	750	33	50	750	15
Boston, Mass.*	...	...	...	...	...	...	...	...	...	50	7 000	24
Cambridge, Mass.	50	1 242	37	50	250	37	50	300	11	50	250	17
Canandaigua, N. Y.	50	248	62	50	290	68	50	180	42	50	146	10
Denison, Tex.	...	...	...	50	153	15	200	799	12	500	3 090	4
Fall River, Mass.	...	...	...	60	328	63	60	457	26	60	1 394	17
Hartford, Conn.	19	560	55	114	659	67	135	1 186	27	98	1 842	24
Hartford, Conn.	75	1 247	24	148	749	43	...	...	...	...	...	...
Holyoke, Mass.	20	2 215	46	15	92	50	20	113	43	...	...	...
Holyoke, Mass.	47	2 118	69 = (apartments with stores)									
Pawtucket, R. I.	...	...	...	...	...	...	482	4 095	26	766	7 188	12
Pawtucket, R. I.	...	...	...	...	...	...	...	...	...	444	4 534	12
Peoria, Ill.	5	150	84	5	30	74	20	80	32	5	15	11
Peoria, Ill.	5	200	63	13	104	47	25	125	28	8	40	6
Plymouth, Mass.	...	...	...	23	94	47	15	67	33	2	4	14
Washington, D. C.	101	3 470	135	84	500	75	100	400	30	100	500	37
Wilmington, Del.	25	500	73	25	189	73	25	125	44	...	...	...
Worcester, Mass.	50	1 875	60	50	277	42	50	385	66	50	1 179	12
Totals	497	15 989	...	727	4 115	...	1 302	9 188	...	2 258	28 016	...
Averages			62			54			34			15

* Lowest-class dwellings, lower figures = those for tenement blocks containing from 15 to 30 families each.

By Mr. G. W. Batchelder, water commissioner at Worcester, Mass., who submitted the following fundamental data relating to the 50 examples examined under each class, —

	Apartment Houses.	First-Class Dwellings.	Middle-Class Dwellings.	Lowest-Class Dwellings.
Sinks	453	72	102	218
Basins	516	169	92	1
Baths	449	102	96	5
Water-Closets	479	156	108	157
Set Wash Tubs	816	135	87	...
Hose	50	58	56	4
Boilers for Heating	40	32	17	...
Tank in House	410	50	76	...
Elevators	18	1	...	...

Mr. Dexter Brackett, chief engineer of the Metropolitan Water Works of Boston, has courteously placed at the disposal of the members of your committee the following data recently prepared by him, based upon the Metropolitan records for the year 1908, with populations based upon the State Census Report for the year 1905.

TABLE 12.

WATER CONSUMPTION IN DWELLINGS OF DIFFERENT CLASSES IN THE METROPOLITAN WATER DISTRICT FOR THE YEAR 1908. POPULATIONS BASED UPON STATE CENSUS OF 1905. (By courtesy of Dexter Brackett, Chief Engineer.)

	Number.	Estimated Population.	Gal. per Capita per Day.
BOSTON, MASS.			
Houses, single*	8	37	140.9 *
2-family	5	48	37.5
3-family	9	129	61.2
4-family	20	382	29.5
5-family	25	598	76.2
6-family	36	1 032	52.2
7-family	31	1 037	35.5
8-family	278	10 631	28.0
9-family	86	3 700	27.5
10-family	65	3 107	50.3
11 to 20-family inclusive	113	7 849	35.3
21 to 30-family inclusive	18	2 199	44.3
Over 30-family	9	1 640	25.1
Combined houses and stores	505	21 410	29.9
		53 799	33.0 Average

* Including some stables and garages. Note the very small number of premises included.

TABLE 12 (*Continued*).

WATER CONSUMPTION IN DWELLINGS OF DIFFERENT CLASSES IN THE METROPOLITAN WATER DISTRICT FOR THE YEAR 1908. POPULATIONS BASED UPON STATE CENSUS OF 1905.

	Number.	Estimated Population.	Gal. per Capita per Day.	
SOMERVILLE.				
Houses, single	1 249	5 283	30.0	
2-family	1 329	11 243	23.9	
3-family	314	3 985	23.8	
4-family	82	1 387	26.1	
Others	98	2 669	27.5	
Boarding houses	15	...	...	
Combined houses and stores	130	1 667	23.5	
		26 234	25.6	Average
MALDEN.				
Houses, single	4 168	18 548	20.0	
2-family	1 799	16 011	14.6	
3-family	108	1 442	18.5	
Others	45	1 018	19.6	
Boarding houses	23	350	20.0	
Combined with stores	105	625	20.0	
	(Estimated)	37 994	17.6	Average
CHELSEA.				
Houses, single	94	431	49.4	
2-family	211	1 937	25.2	
3-family	494	6 804	25.9	
4-family	62	1 139	21.9	
Others	46	1 253	25.8	
Boarding houses	2	...	...	
Combined houses and stores	209	2 373	24.9	
		13 937	26.1	Average
EVERETT.				
Houses, single	20	87	41.2	
2-family	4	35	27.1	
3-family	10	130	27.7	
Others	3	82	49.3	
Houses combined with stores	14	61	14.8	
		395	33.1	Average
QUINCY.				
Houses, single	1 151	5 456	27.4	
2-family	204	1 934	22.2	
3-family	30	427	17.9	
Others	6	200	27.0	
Boarding houses	27	310	25.0	
Combined houses and stores	13	64	24.9	
		8 391	25.6	Average

TABLE 12 (*Continued*).

WATER CONSUMPTION IN DWELLINGS OF DIFFERENT CLASSES IN THE METROPOLITAN WATER DISTRICT FOR THE YEAR 1908. POPULATIONS BASED UPON STATE CENSUS OF 1905.

	Number.	Estimated Population.	Gal. per Capita per Day.
MEDFORD.			
Houses, single	168	739	32.3
2-family	220	1 936	22.7
3-family	21	277	23.7
Others	6	123	21.0
Combined houses and stores	39	484	23.2
Boarding houses	8	...	...
		3 559	24.8 Average
Private lawns	3		
MELROSE.			
Houses, single	884	3 740	29.5
2-family	18	152	44.7
Others	9	173	31.6
Combined houses and stores	20	169	31.7
		4 234	30.2 Average
REVERE.			
Houses, single	60	266	40.9
2-family	28	248	36.5
3-family	32	424	33.9
		938	36.6 Average
WATERTOWN.			
Houses, single	1 023	4 869	19.5
2-family	475	4 522	15.0
3-family	34	486	12.5
4-family	31	588	14.6
Others	16	500	12.9
Boarding houses	11	154	14.2
Combined houses and stores	30	180	15.7
		11 299	16.7 Average
ARLINGTON.			
Houses, single	452	2 133	34.0
2-family	172	1 624	28.7
3-family	26	368	32.6
Others	11	255	34.5
Combined houses and stores	2	24	29.9
Boarding houses	6	...	...
		4 404	31.9 Average
Private lawns	5		

TABLE 12 (*Continued*).

WATER CONSUMPTION IN DWELLINGS OF DIFFERENT CLASSES IN THE METROPOLITAN WATER DISTRICT FOR THE YEAR 1908. POPULATIONS BASED UPON STATE CENSUS OF 1905.

	Number.	Estimated Population.	Gal. per Capita per Day.
WINTHROP.			
Houses, single	29	124	47.2
2-family	18	154	40.7
3-family	7	90	34.4
Others	5	120	15.5
		488	35.3 Average
MILTON.			
Houses, single	996	4 751	29.8
2-family	122	1 164	14.9
3-family	3	43	22.6
4-family	2	38	10.6
Boarding houses	1	...	...
Combined houses and stores	1	4	9.0
		6 000	26.7 Average
SWAMPSCOTT.			
Houses, single	551	2 149	37.2
2-family	81	632	27.2
3-family	3	35	27.0
Others	1	24	27.3
Combined houses and stores	5	31	27.0
Boarding houses	1	...	...
		2 871	34.7 Average
LEXINGTON.			
Houses, single	80	355	38.3
2-family	2	18	41.1
		373	38.4 Average
BELMONT.			
Houses, single	433	2 169	23.8
2-family	134	1 342	17.1
3-family	36	540	17.1
Others	14	301	18.4
Boarding houses	1	...	...
Combined houses and stores	4	50	15.4
		4 402	20.5 Average
NAHANT.			
Houses, single	88	370	73.9
Others	2	34	39.0
		404	68.6 Average

In Table 13 are shown some Wisconsin data courteously furnished by Mr. Frank A. Newton, formerly assistant statistician of the Wisconsin Railroad Commission.

TABLE 13.

WATER CONSUMPTION DATA, FROM WISCONSIN.

(By courtesy of Mr. Frank A. Newton, Assistant Statistician, Wisconsin R. R. Commission, April, 1912.)

Madison, Wis.

(Practically all metered.)

Class.	No.	Average Consumption in Cubic Feet per Year.		Average Consumption in Gal. per Day per Capita.*
		Per Meter.	Per Consumer.	
Residence	3 009	4 109	4 099	21
Flat buildings.				
1-flat	77	3 887	3 887	20
2-flat	1 328	5 143	2 572	14
3-flat	150	11 340	3 780	19.5
4-flat	44	10 413	2 603	13.5

Jefferson, Wis. All consumers metered.

Population about 3 000. No large industrial users. Large number have no sewer connections. Total residence consumers, 200.

92 used between 2 000–5 000 cu. ft. per year.

46 used between 2 000–3 000 cu. ft. per year.

84 used less than 2 000 cu. ft. per year.

Average (4 persons to family) for residence consumers = 14.2 gal. per day per capita.

Janesville, Wis. Thirty per cent. metered — three fourths of meters on residences.

Residences having meters a selected class, having lawn sprinkling connections. Average use per residence per day = 105 gal.

Superior, Wis.

Sold through meters, 245 335 500 gal.

Of 4 360 commercial and industrial consumers, 3 142 are metered.

3 100 commercial metered consumers.

* Assuming 4 persons to the family.

Deducting metered industrial sales there were about 163 000 000 gal. delivered to commercial meters.

Sales per metered commercial use, 52 870 gal. per year.

Sales per metered commercial use, 144 gal. per day.

At Elmira, N. Y., it was found that the average consumption registered by 2 124 meters, during the year ending February 1, 1912, was 19.6 U. S. gal. per day per capita, on the basis of 5.7 persons per consumer.

In a recent rating case (1912) Mr. William C. Hawley, superintendent of the Pennsylvania Water Company, analyzed the records of 2 000 consumers picked at random from the ledgers of the company, for the purpose of comparing the rates charged and based upon the actual amount of water consumed with the flat rates which the company might have charged under its contract, and with the flat rates charged by the city of Pittsburgh at the present time. These 2 000 consumers were divided among 17 districts, in proportion to the number of the consumers in each district, and in general every sixth consumer was taken throughout the entire list. If it was found that any particular consumer was a mixed or commercial consumer, or that the meter had not registered during the full term, or if there was any other cause making the account unfair for comparative purposes, the account of the next consumer was taken; and in this way there was obtained an impartial record of metered domestic water consumption, confined to houses and a very few flats or apartments. The total consumption by the 2 000 consumers, for the period of one year, was found to be 10 441 208 cu. ft., or 5 221 cu. ft. per year per consumer, which is equivalent to 39 155 gal. per year per consumer, or 107 gal. per day per consumer, which, on the basis of 5 persons per house, which is probably a little low, is equivalent to 21.4 gal. per day per capita.

By courtesy of Mr. Hofmeister, of the American Water Works and Guarantee Company, record has been obtained of the domestic water consumption in another city located in the vicinity of Pittsburgh. The average consumption of 4 801 domestic services was (1912) 116 gal. per day per tap, or probably slightly less than 23 gal. per capita per day.

In six other places in this vicinity, with a total number of taps in

each, ranging from a little over 1 000 to slightly less than 5 000, for a total number of 17 222 taps, the consumption ranged from 78 gal. per tap per day, for the smallest, to 116 for the largest of these communities, the weighted average per tap being 99.5 gal. per tap per day. Upon the basis of five persons per tap, this gives an average use of 20 gal. per day per capita. The properties considered in these communities were dwellings, — commercial, industrial, and apartment houses being excluded.

In works serving in the year 1912 approximately 237 000 population, in one of the leading coal mining districts of Pennsylvania, it was found that while the per capita consumption was approximately 122 gal. per day, the average domestic consumption for approximately 150 000 population was but 89 gal. per day per consumer, or 17 gal. per day per capita.

At Champaign and Urbana, Ill., where the University of Illinois is located, the average metered domestic consumption based upon 27 600 population and 3 246 consumers, was 122 gal. per day per consumer, or 15.4 gal. per day per capita.

An interesting investigation of the water consumption of 390 typical water services at Pittsburgh, Pa., upon which meters had recently been installed, was made by Mr. Morris Knowles, in 1911, incident to the Pennsylvania Water Company rating case referred to above:

Mr. Emil Kuichling, March 11, 1912, has furnished the following facts concerning observations made at Rochester, N. Y.

"Another interesting record of purely domestic consumption in Rochester, N. Y., is afforded by an examination of 101 meter accounts of small dwellings, which was made in February, 1910, at my request by Mr. B. C. Little, C.E., superintendent of the water works. The data are as follows:

	Gallons per Head per Day.
32 Services into dwellings having both water-closet and bath, and averaging 3 occupants each	22.0
34 Services into dwellings having water-closet, but no bath, and averaging 4 occupants each	16.0
35 Services into dwellings having neither water-closet nor bath, and averaging 4 occupants each	14.5
Total, 101 Services running into as many dwellings, having an aggregate of 372 occupants, and consuming an aggregate of 6 318 gallons per day on the average	17.0

"In this list only 13 services used less than 10 gal. per head per day, the smallest consumption being in a household of 8 persons using 7.0 gal. per head per day on the average throughout the year.

"Mr. Little also remarks that in the better class of dwellings the per capita consumption, according to the meter records, ranges from 25 to 150 gal. per day. In his own household of six persons (including two maids), residing in a 10-room dwelling with 3 bathrooms, the average consumption is 41 gal. per head per day; and he adds that the water fixtures therein are kept in good order."

At New Orleans, Mr. George G. Earl reports that of the ordinary domestic consumers using $\frac{5}{8}$-inch meters, about one third use less than 75 gal. per day, one third use from 75 to 170 gal. per day, and one third above 170 gal. per day. Assuming families of five, this indicates that one third of the small consumers use less than 15 gal. per capita per day, one third from 15 to 35 gal., and one third over 35 gal. In other words, in New Orleans the present average consumption is about 35 gal. per capita per day, for ordinary domestic consumers.

TABLE 14.

MEMORANDA OF AN INVESTIGATION OF 390 TYPICAL WATER SERVICES AT PITTSBURGH, PA.
(Courtesy of Mr. Morris Knowles and the Pennsylvania Water Company.)

During the year 1911 a study was made of 390 services in the city of Pittsburgh, for the purpose of ascertaining the relation of charges on a flat-rate basis to those on a meter basis. The services investigated were picked to cover all classes of domestic use and all sections of the city. The data as to flat assessment, meter readings, amount of charges, and number of rooms in the house were taken from the water assessor's book. The number of persons residing on the premises supplied was obtained by visits to the property.

The investigation was confined to residential properties only, no flat buildings, tenement houses, residences, and stores or any place of business were included. The services include all those paying for water on a meter basis with a rate of 18 cents per 1 000 gallons. The placing of meters being optional on the part of the consumer in Pittsburgh, the majority of domestic consumers are on the flat-rate schedule.

The tabulation is made in the order of flat-rate assessment, assuming that the class of service furnished is gaged somewhat by the charge which would have been made if assessed on the flat-rate basis.

Flat Rate. Dollars.	Services Investigated.	No. of Persons.	No. of Rooms.	Av. No. of Persons per Service.	Total Gallons Water used Yearly.	Average Gallons per		
						Service per Year.	Person per Day.	Service per Day.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$3 to $4	1	5	3	5.0	24 400	24 400	13	67
4 to 5	4	20	16	5.0	95 700	23 920	13	66
5 to 6	3	18	17	6.0	185 500	61 830	28	169
6 to 7	8	33	43	4.1	253 600	31 700	21	87
7 to 8	12	52	56	4.3	347 400	28 950	18	79
8 to 9	14	67	84	4.8	597 200	42 660	24	117
9 to 10	26	142	160	5.5	910 300	35 010	17	96
10 to 11	31	156	191	5.0	1 686 000	54 390	30	149
11 to 12	29	135	202	4.7	1 133 400	39 080	23	107
12 to 13	8	40	55	5.0	471 000	58 870	32	161
13 to 14	9	42	67	4.7	418 400	46 480	27	127
14 to 15	8	50	61	6.2	302 500	37 810	17	104
15 to 16	16	57	104	3.6	762 500	47 660	36	130

TABLE 14 (*Continued*).

MEMORANDA OF AN INVESTIGATION OF 390 TYPICAL WATER SERVICES AT PITTSBURGH, PA.

Flat Rate. Dollars.	Services Investigated.	No. of Persons.	No. of Rooms.	Av. No. of Persons per Service.	Total Gallons Water used Yearly.	Average Gallons per		
						Service per Year.	Person per Day.	Service per Day.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$16 to $17	17	64	122	3.8	706 800	41 580	30	114
17 to 18	15	72	129	4.8	771 700	51 450	29	141
18 to 19	12	65	101	5.4	889 400	74 120	38	203
19 to 20	13	57	108	4.4	581 200	44 710	28	123
20 to 21	13	51	111	3.9	1 079 500	83 040	58	228
21 to 22	18	87	161	4.8	1 378 000	76 550	44	210
22 to 23	15	83	157	5.5	1 364 000	90 930	45	249
23 to 24	11	65	106	5.9	947 600	86 150	40	236
24 to 25	13	70	125	5.4	814 500	62 660	32	172
25 to 26	8	36	66	4.5	409 000	51 120	31	140
26 to 27	15	84	119	5.6	1 359 600	90 640	44	248
27 to 28	13	73	91	5.6	1 197 000	92 080	45	252
28 to 29	8	41	73	5.1	569 000	71 130	38	195
29 to 30	6	37	46	6.2	508 200	84 700	37	232
30 to 31	4	23	38	5.7	437 200	109 300	52	299
31 to 32	8	41	89	5.1	880 000	110 000	59	302
32 to 33	5	21	55	4.2	614 200	122 840	80	336
33 to 34	2	12	24	6.0	200 500	100 250	46	275
34 to 35	8	38	83	4.7	861 500	107 690	63	295
35 to 36	2	9	18	4.5	179 100	89 550	55	245
36 to 37	2	8	20	4.0	260 500	130 250	89	357
38 to 39	1	5	11	5.0	90 400	90 400	50	248
39 to 40	1	6	12	6.0	226 100	226 100	103	619
40 to 41	3	22	31	7.3	450 100	150 030	56	410
41 to 42	1	4	14	4.0	132 700	132 700	91	364
42 to 43	1	4	13	4.0	91 900	91 900	63	252

TABLE 14 (*Continued*).

MEMORANDA OF AN INVESTIGATION OF 390 TYPICAL WATER SERVICES AT PITTSBURGH, PA.

Flat Rate. Dollars.	Services Investigated.	No. of Persons.	No. of Rooms.	Av. No. of Persons per Service.	Total Gallons Water used Yearly.	Average Gallons per		
						Service per Year.	Person per Day.	Service per Day.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$48 to $49	1	7	8	7.0	77 200	77 200	30	212
51 to 52	1	4	10	4.0	188 400	188 400	129	516
59 to 60	1	4	12	4.0	231 700	231 700	159	635
80 to 81	1	13	26	13.0	468 700	486 700	102	1 332
86 to 87	1	3	20	3.0	65 600	65 600	60	180
97 to 98	1	5	13	5.0	84 700	84 700	46	232
	390	1 931	3 071	5.0	25 303 900	64 900	35	178

Floor Area as a Basis for Estimating Water Consumption.

W. W. Brush, in charge of the design of the delivery system to carry the Catskill water to the five boroughs of New York, found the per capita basis of estimating water consumption to be very uncertain in some parts of New York City.

Various gagings of the consumption in different classes of buildings are shown in the following tables taken from his paper.

TABLE 15. Consumption of Water in Various Classes of Buildings in New York City.

(From *Engineering News*, June 13, 1912, page 1132.)

No. of District.	Characteristics of Occupancy.	Consumption. Mgd.	Population, Resident.	Consumption per Capita. Gal.
	Gagings in 1902–03.			
1	Large hotels, high-class residences	1.87	8 396	223
2	East Side tenements	1.44	38 906	37
3	East Side tenements	5.40	90 000	60
6	Residence and high-class apartments	0.76	10 164	75
8	Business, office buildings, waterfront, shipping	9.45	11 000	860
9	High-class apartments and hotels	1.37	8 872	154
10*	East Side tenements, some waterfront	20.20	218 023	93
11	Uptown residences and medium-class apartments	4.89	4 380	112
12	Upper East Side tenement, waterfront, power houses, and breweries	2.75	39 969	69
	Gagings in 1911.			
1a	East Side tenement, some waterfront (same as district No. 10)	11.44	230 500	50
2a	All classes	29.48	204 557	144
3a	High-class apartments and residences	22.18	186 990	118
4a	High-class apartments, residences, and tenements	12.74	138 800	92
5a	East Side tenement and waterfront	8.28	84 580	98
6a	High-class apartments, residences, tenements, and waterfront	14.82	173 000	86
7a	All classes	13.38	169 100	79
8a	All classes	13.66	209 393	65

* An error was later discovered in the measurement of flow in this district, which reduced the consumption as given by about 50 per cent.

It will be seen that on the per capita basis the consumption varied from 37 gal. per capita per day, in certain East Side tenements, to 860 gal. per capita per day in some of the office buildings.

This resulted in the adoption of the floor area basis of water consumption, using a unit of 1 000 sq. ft., for the following reasons:

"The amount of water used in any building is proportional to the size and height of same.

"The total floor area could readily be obtained from available atlases.

"Very large areas, especially in the Borough of Manhattan, are occupied only for business purposes.

"A large and increasing part of the population, especially in the Borough of Manhattan, is transient, and, therefore, cannot be accurately determined for the present nor for the future.

"Several hundred thousand people in Manhattan engaged in business, make their homes in adjoining sections of New York State and New Jersey.

. . . . . .

"It was found, upon examination, that, with the exception of those buildings where the consumption of water would be unusually high, such as hotels, laundries, ice plants, etc., the use of water per 1 000 ft. of floor area was 150 to 300 gal. per day."

A comparison of a high-class apartment house district and a low-class tenement district gave, on the per capita basis, a consumption of 154 gal. and 37 gal. respectively, while on the basis of 1 000 sq. ft. floor area, the respective consumptions were 181 and 179 gallons.

"While this close agreement in consumption for the two districts was a coincidence, it strikingly illustrated the uniformity obtained from the floor-area basis as compared with the per capita basis, in two residential districts where the character of population varied widely."

As a result of this study, the following assumptions were decided upon:

TABLE 16. ASSUMED FUTURE WATER CONSUMPTION IN NEW YORK CITY.

(*Engineering News*, June 13, 1912, page 1132.)

Section.	Average Height of Building, Stories.	Percentage of Block Built Upon.	Consumption per 1 000 sq. ft. of Floor Area, Gal. Daily.
South of 23d Street	8	85	350
23d to 46th Street	10	85	350
49th to 59th Street	8	85	350
59th Street to Spuyten Duyvil	6	75	300

THE EFFECT OF THE INTRODUCTION OF SEWERS UPON WATER CONSUMPTION in any community is indicated by the experience in Marlborough, Newton, and Waltham, Mass., shown in Table 17, and by similar figures for residences, with and without sewer connections, located in Madison, Wis.

TABLE 17.

AVERAGE CONSUMPTION OF WATER IN THREE MASSACHUSETTS CITIES BEFORE AND AFTER THE INTRODUCTION OF A FAIRLY COMPLETE SYSTEM OF SEWERS.

(By courtesy of X. H. Goodnough, Chief Engineer, Massachusetts State Board of Health.)

City.	Gallons per Person per Day.																	
	Years Previous to Introduction of Sewers.							Year when System of Sewers was Practically Completed. (1891.)	Years Subsequent to Introduction of Sewers.									
	7	6	5	4	3	2	1		1	2	3	4	5	6	7	8	9	19
Marlborough.....	13	17	20	21	24	24	25	26	30	30	35	34	37	37	38	38	36	37
Newton.....	28	31	33	33	31	36	40	43	50	52	60	65	63	60	57	63	62	63
Waltham.....	37	36	39	33	31	32	33	40	47	53	61	59	71	70	76	88	90	88

TABLE 18.

CONSUMPTION OF WATER IN MADISON, WIS., IN RESIDENCES WITHOUT AND WITH SEWER CONNECTIONS.

(By courtesy of Mr. Frank A. Newton.)

No. of Services.	Total Consumption. Cubic Feet per Year.	Average Consumption. Gallons per Day per Service.
Residences without Sewer Connections.		
23	8 444	7.5
33	21 960	13.7
5	5 544	22.8
2	3 346	34.4
1	2 300	47.3
1	2 977	61.2
65	44 571	
Average.....	685.8*	14.1
Residences with Sewer Connections.		
2 634	3 788*	68.0

* Average per service.

THE EFFECT UPON DOMESTIC CONSUMPTION OF THE INSTALLATION OF METERS is interestingly shown by the following diagrams, Figs. 1, 2, and 3, prepared by Metcalf & Eddy for the report of the Sewage Disposal Commission of Milwaukee, 1910.

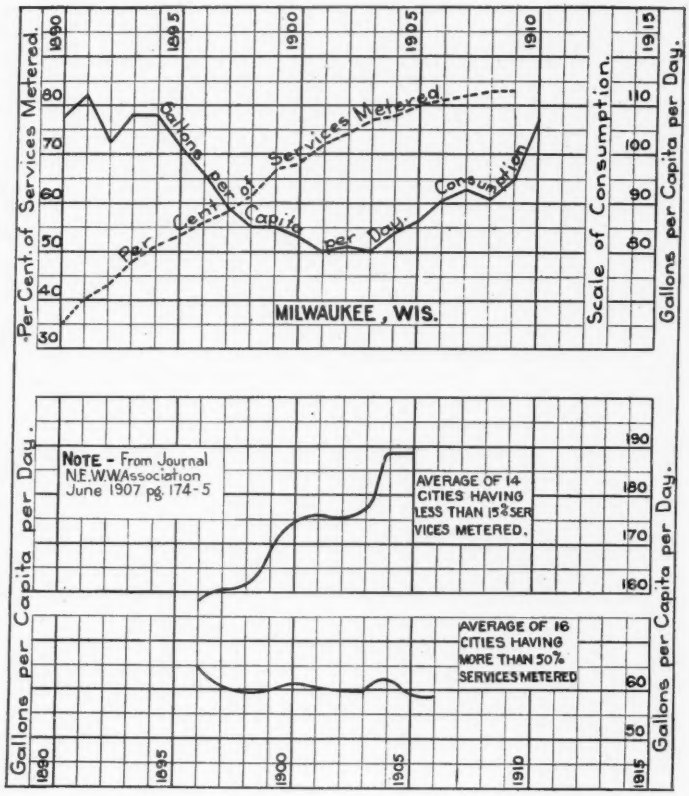

Per Cent of Services Metered.
Gallons per Capita per Day.
Scale of Consumption.
Gallons per Capita per Day.
Per Cent of Services Metered
Gallons per Capita per Day
Consumption
MILWAUKEE, WIS.
NOTE - From Journal N.E.W.W.Association June 1907 pg. 174-5
AVERAGE OF 14 CITIES HAVING LESS THAN 15% SERVICES METERED.
AVERAGE OF 16 CITIES HAVING MORE THAN 50% SERVICES METERED
Gallons per Capita per Day.
Gallons per Capita per Day.

FIG. 1.

WATER CONSUMPTION IN VARIOUS CITIES.

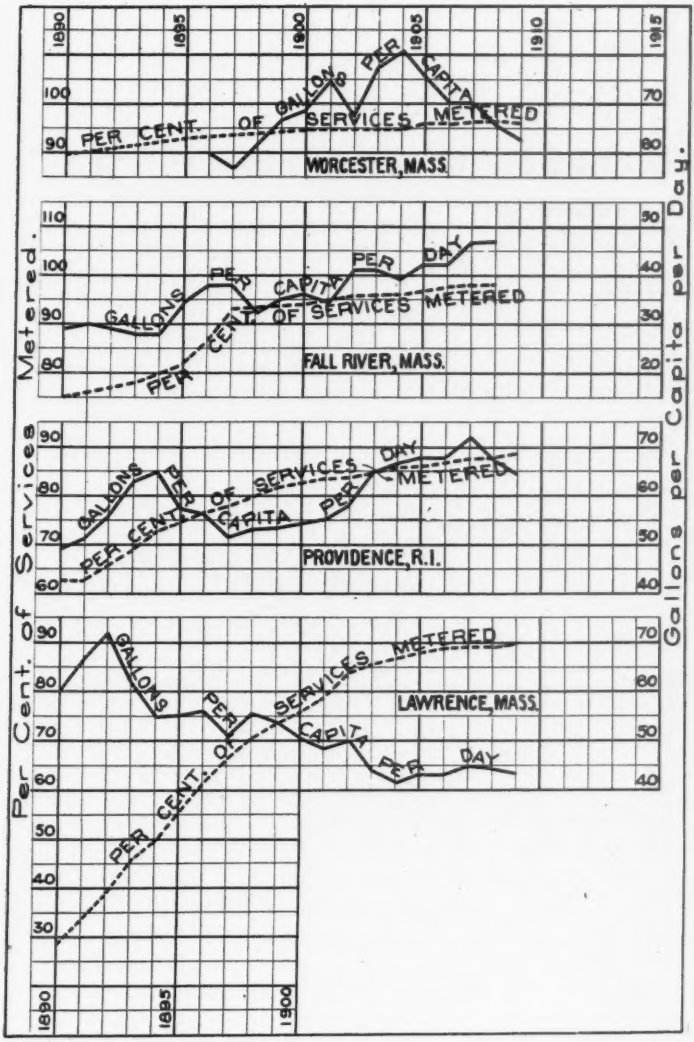


FIG. 2.

WATER CONSUMPTION IN VARIOUS CITIES.

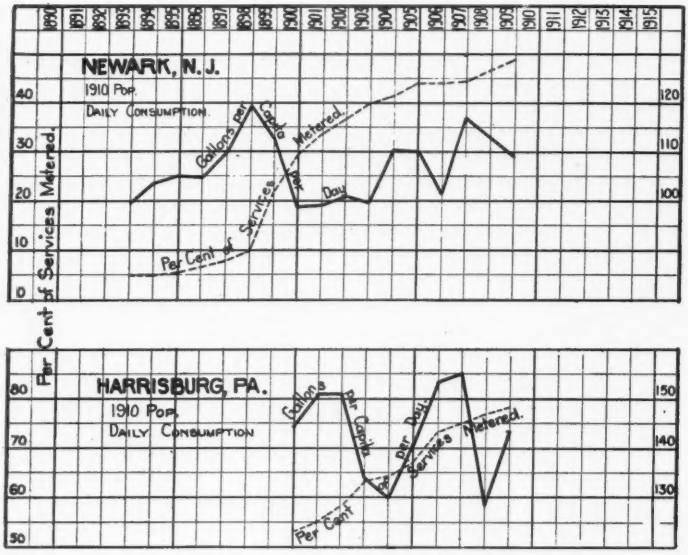


FIG. 3.

WATER CONSUMPTION IN VARIOUS CITIES.

Mr. William S. Johnson, in a valuable paper upon water consumption,* quoted the following per capita consumption statistics for the year 1905:

TABLE 19.

AVERAGE PER CAPITA CONSUMPTION OF WATER, 1905.

(Cities in United States larger than 25 000 population.)	
34 cities, not over 10 per cent. of taps metered,	146 gal. per day.
23 cities, 10 to 25 per cent. of taps metered,	97 gal. per day.
18 cities, 25 to 50 per cent. of taps metered,	89 gal. per day.
14 cities, 50 to 75 per cent. of taps metered,	89 gal. per day.
19 cities, more than 75 per cent. of taps metered,	72 gal. per day.
(Cities and towns in United States smaller than 25 000 population.)	
26 places, not over 25 per cent. of taps metered,	77 gal. per day.
12 places, 25 to 50 per cent. of taps metered,	63 gal. per day.
9 places, 50 to 75 per cent. of taps metered,	45 gal. per day.
22 places, over 75 per cent. of taps metered,	48 gal. per day.

NUMBER OF CONSUMERS ON MINIMUM RATE, AND NUMBERS PAYING DIFFERENT RATES.

One of the most difficult matters to forecast in the operation of a new rate schedule — particularly in passing from a flat rate to a meter schedule — is the number of consumers which will fall within the class of minimum rate payers, though fortunately the disastrous effect of erroneous assumptions in this direction may be offset by the maintenance, temporarily at least, of a high annual minimum charge. This difficulty is clearly indicated by Table 20, showing the variation found in different communities in the percentage of consumers who are minimum rate payers.

*JOURNAL N. E. W. W. A., Vol. 21, page 109.

TABLE 20.

DATA RELATING TO CHARGES FOR METERED WATER.

(*Condensed from Report of the New England Water Works Association Committee on Meter Rates, presented September 13, 1905.**)

No.	City or Town.	Total Number of Services.	Number of Metered Services.	Percentage of Metered Services.	Minimum Annual Meter Charge, in Dollars.	Amount of Water Allowed for Minimum Charge.	Number of Services using Less than This Allowance.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Atlantic City, N. J.	4 636	3 943	85	.....	.....	3 159
2	Attleboro, Mass.	....	1 567	100	$6.00	2 600 cu. ft.	406
3	Bath, Me.	2 060	105	5	20.00	8 000 cu. ft.	65
5	Billerica, Mass.	264	142	54	12.00	40 000 gal.	71
7	Bristol, Conn.	1 250	44	4	25.00	8 330 gal.	7 or 8
8	Brockton, Mass.	5 849	5 299	91	8.00	27 000 gal.	.....
9	Burlington, Vt.	3 524	2 680	76	6.00	4 000 cu. ft.	About 1 100
10	Claremont, N. H.	822	152	19	12.00	60 000 gal.	10
11	Cleveland, Ohio	60 627	30 226	49	2.50	47 000 gal.	11 000
12	Clinton, Mass.	1 743	1 417	82	6.00	2 400 cu. ft.	About 225
13	Concord, N. H.	3 376	1 272	38	2.50	1 700 cu. ft. per quar.	597
15	Des Moines, Ia.	9 509	6 500	68	4.00	150 cu. ft. per mo.	775
16	Detroit, Mich.	61 465	5 847	10	1.75 per quar.	30 000 gal.	.....
17	E. Providence, R. I.	993	686	69	10.00	33 333 gal.	400
18	Fairhaven, Mass.	600	200	33	10.00	33 000 gal.	.....
19	Fitchburg, Mass.	4 695	2 712	58	10.00	.....	1 000
20	Gloucester, Mass.	3 490	160	5	2.00	67 000 gal.	.....
21	Gloversville, N. Y.	3 186	300	9	4.00	.....	Very few
22	Greensburg, Pa.	2 424	2 656	100	12.00	20 000 gal.	.....
23	Hartford, Conn.	10 000	9 600	96	5.00	.....	.....
24	Haverhill, Mass.	5 650	662	12	10.00	128 gal. per day	Four fifths
26	Indianapolis, Ind.	14 240	900	6	16.20	7 500 gal. per mo.	.....
27	Jacksonville, Fla.	3 270	1 706	52	8 and 12	300 gal. per day	.....

28	Kewanee, Ill.	600	600	100	5.00	1 700 cu. ft. per year	se 33⅓ per cent.
29	Knoxville, Tenn.	5 660	1 677	30	10.00	33 000 to 40 000 gal. per year	.
30	Leominster, Mass.	2 353	711	30	10.00	5 000 cu. ft.	.....
31	Manchester, N. H.	6 000	4 000	67	10.00	8 000 cu. ft.	300
32	Marion, Ohio	891	653	73	2.50 per quar.	10 000 gal. per quar.	About 60 per cent.
33	Marlboro, Mass.	2 258	1 266	56	6.00	1 777 cu. ft.	.....
34	Milton	1 173	1 173	100	8 and 16	2 400 & 4 800 cu. ft.	.....
35	Montclair, N. J.	2 650	2 650	100	10.00	4 445 cu. ft.	About ½
37	Muscatine, Ia.	1 240	100	8	10.00	25 000 gal.	None
38	Nashua, N. H.	†4 000	657	16	16.00	80 000 gal.	.....
39	New Bedford, Mass.	9 927	1 954	19	5.00	33 333 gal.	Quite a number
40	New London, Conn.	3 463	278	8	10.00	33 333 gal.	Few
41	Newton, Mass.	7 404	6 367	86	10.00	28 571 gal. and up	About 40 per cent.
43	Oberlin, Ohio	700	512	73	5.00	2 240 cu. ft.	About 100
44	Paterson, N. J.	11 735	3 054	26	12.00	1 300 cu. ft. per quar.	About 60 per cent.
45	Portland, Conn.	550	30	6	15.00	60 000 gal.	None
46	Portland, Ore.	19 473	750	4	Fixture rate	Quantity paid for by schedule rate	About ½
47	Quincy, Mass.	5 327	165	3	18 per year	60 000 gal.	75 per cent.
48	Reading, Mass.	1 162	1 035	89	6 per year	16 000 gal.	604
50	Rockville, Conn.	....	239	...	6.00	25 000 gal.	.....
52	Somerville, Mass.	11 059	1 537	14	1.50 per quar.	1 250 cu. ft.	Few
55	Stapleton, N. Y.	3 267	1 500	46	$2.50 per quar.	740 cu. ft. per quar.	About ½ per cent.
56	Syracuse, N. Y.	18 988	10 063	53	5.00	3 600 cu. ft. per an.	5 000
57	Tarrytown, N. Y.	700	678	96	1 per quar.	333 cu. ft.	95
58	Taunton, Mass.	4 753	2 134	45	10.00	40 000 gal.	900
59	Waterbury, Conn.	5 388	518	10	5.00	17 000 gal.	10
61	Watertown, Mass.	1 730	1 595	92	10.00	4 000 cu. ft.	656
62	Wellesley, Mass.	916	911	99	6.00	16 000 gal.	300
63	Westboro, Mass.	648	630	97	5.00	16 724 gal. per an.	225

*See JOURNAL N. E. W. W. A., Vol. 19, p. 334.

†About.

TABLE 20 (*Continued*).

DATA RELATING TO CHARGES FOR METERED WATER.

No.	City or Town.	Total Number of Services.	Number of Metered Services.	Percentage of Metered Services.	Minimum Annual Meter Charge in Dollars.	Amount of Water Allowed for Minimum Charge.	Number of Services using Less than This Allowance.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
64	Westerly, R. I.	1 375	1 088	80	$10.00	33 333⅓ gal. per an.	767
65	Whitman, Mass.	1 058	5 010	47	6.00	30¢ per 1 000 gal.	¼ (perhaps)
66	Winooski, Vt.	282	254	90	2 per quar.	1 000 cu. ft.	119
68	Woonsocket, R. I.	2 557	2 251	88	10.00	33 333 gal.	893
69	Worcester, Mass.	14 129	13 386	95	4.00	16 000 gal. per an.	Quite a large number
72	York, Pa.	10 060	293	3	1 per mo.	3 333 gal. per mo.	66

NOTE. Cities omitted are those for which the data, under the headings here used, were incomplete.

Further data along this line, relating to cities and towns in Wisconsin, have been furnished by Mr. Frank A. Newton, formerly assistant statistician of the Wisconsin Railroad Commission (1912).

TABLE 21.

WATER CONSUMPTION DATA.

(By courtesy of Mr. Frank A. Newton, Assistant Statistician, Wisconsin Railroad Commission, April, 1912.)

Distribution of Sales. Per Cent.

Cu. Ft.	Superior.	Marshfield.*	Richland Center.	Evansville.
1st 1 000	39.2	7.3	40.2	54.1
Next 2 000	11.7	6.4	36.0	23.0
Next 7 000	12.3	7.4	20.5	19.6
1st 10 000	63.2	21.1	96.7	96.7
Next 15 000	10.3	6.5		
Next 25 000	9.4	6.2		
Next 50 000		8.1	3.3	3.3
Next 100 000	17.1	12.8		
Over 200 000		45.3		

Milwaukee Water Consumers.

(Single Residences.)

11 765 consumers used less than 600 cu. ft. during some quarters. Consumption for year by this class = 34 787 400 cu. ft.

Average: 2 957 cu. ft. per consumer per year.

Average: 7.1 cu. ft. per consumer per day.

Average: 53.3 gal. per consumer per day.

Consumers using more than 600 cu. ft. every quarter, — second quarter:

4 432 — under 1 000 cu. ft.	3 725 600
16 884 — 1 000 to 5 000	35 021 600
851 — 5 000 to 25 000	6 935 600
44 — 25 000 to 100 000	2 124 200
6 — over 100 000	1 637 200
22 217	49 444 200

2 225 cu. ft. per consumer per quarter.

24.7 cu. ft. per consumer per day.

185.3 gal. per consumer per day.

* The Marshfield record is misleading by reason of one or two very large consumers. When correction is made for these consumers the percentage closely approximates those given for the other cities named.

Fourth quarter:

6 036	— under 1 000	4 645 600
15 403	— 1 000 to 5 000	49 407 900
756	— 5 000 to 25 000	6 239 200
42	— 25 000 to 100 000	1 837 200
7	— over 100 000	2 001 700
22 244		64 131 600

2 882 cu. ft. per consumer per quarter.
32 cu. ft. per consumer per day.
240 gal. per consumer per day.

49 444 200		
64 131 600		
113 575 800		
2		
227 151 600	11 765	
34 787 000	22 220	
261 938 600	33 985 cons.	7 707 cu. ft. per consumer per year.

21.1 cu. ft. per consumer per day. 158.3 gal. per consumer per day.

TABLE 22.

WATER CONSUMPTION DATA FOR JEFFERSON, WIS.

(From Reports Wisconsin Railroad Commission, 1910, Vol. 74, Jefferson, Wis., Municipal Light and Water Plant, p. 580.)

Residence Consumers.

Cu. Ft. per Year per Service.	No. of Services.	Gal. per Day per Service.
300 to 400	1	7.2 ± 14 per cent.
400 to 500	4	9.3 ± 11 per cent.
500 to 600	3	11.3 ± 9 per cent.
600 to 700	3	13.4 ± 8 per cent.
700 to 800	12	15.4 ± 7 per cent.
800 to 900	4	17.5 ± 6 per cent.
900 to 1 000	9	19.6 ± 5 per cent.
1 000 to 1 100	4	21.6 ± 5 per cent.
1 100 to 1 200	5	23.6 ± 4 per cent.
1 200 to 1 300	6	25.7 ± 4 per cent.
1 300 to 1 400	6	27.8 ± 4 per cent.
1 400 to 1 500	5	29.8 ± 3 per cent.
1 500 to 1 600	4	31.9 ± 3 per cent.
1 600 to 1 700	3	33.9 ± 3 per cent.
1 700 to 1 800	2	36.0 ± 3 per cent.
1 800 to 1 900	4	38.2 ± 3 per cent.
1 900 to 2 000	9	40.2 ± 3 per cent.
2 000 to 3 000	46	51.4 ± 2 per cent.
3 000 to 4 000	29	72.1 ± 1 per cent.
4 000 to 5 000	17	92.5 ± 1 per cent.
5 000 to 6 000	11	113.0 ± 1 per cent.
6 000 to 7 000	5	133.9 ± 1 per cent.
7 000 to 8 000	4	154.4 ± 1 per cent.
8 000 to 9 000	1	175.0 ± 1 per cent.
9 000 to 10 000	1	195.5 ± 1 per cent.
over 10 000	2	200.6
	200	

Weighted average, 58.2

In this connection reference may also be had to an interesting description by Mr. J. Herbert Shedd, published in the JOURNAL of this Association, March, 1904, of conditions prevailing in Providence, R. I., in the year 1888.

Similar conditions are found in the works purveying water upon flat-rate bases, as is indicated by the amount paid per annum by different classes of houses. Thus a recent publication by the Water Bureau of Philadelphia in "Water Educational Series," booklet No. 2, February, 1912, gives the following subdivision of total water received for the year 1911.

TABLE 23.

Classification of Philadelphia's Water Revenue Accounts by Amounts.

(From Water Supply Educational Series, Booklet No. 2.)

A. Total water receipts from all sources for 1911		$4 800 000
which were divided approximately as follows:		
From residences	$3 100 000	
From industries and other large consumers	1 400 000	
From miscellaneous (mostly pipe frontage)	300 000	
		$4 800 000
B. Total water receipts from residences for 1911		$3 100,000
which were divided approximately as follows:		
2 500 accounts from $17.00 to $100.00	$100 000	
20 000 accounts at 16.00 each	320 000	
7 000 accounts at 15.00 each	105 000	
18 000 accounts at 14.00 each	252 000	
28 000 accounts at 13.00 each	364 000	
22 000 accounts at 12.00 each	264 000	
20 000 accounts at 11.00 each	220 000	
37 000 accounts at 10.00 each	370 000	
65 000 accounts at 9.00 each	585 000	
24 000 accounts at 8.00 each	192 000	
4 000 accounts at 7.00 each	28 000	
22 000 accounts at 6.00 each	132 000	
29 200 accounts at 5.00 each	146 000	
11 000 accounts at 2.00 each	22 000	
309 700 accounts		$3 100 000
C. Total water receipts from industries (and other large consumers) for 1911		$1 400 000
which were divided approximately as follows:		
60 accounts $2 000 to $50 000	$400 000	
80 accounts 1 000 to 2 000	115 000	
200 accounts 500 to 1 000	125 000	
1 360 accounts 100 to 500	280 000	
13 600 accounts 17 to 100	480 000	
15 300 accounts		$1 400 000

A city in central New York reports the following schedule of flat-rate consumers for the year 1911:

TABLE 24.

CLASSIFICATION OF FLAT-RATE WATER CONSUMERS FOR YEAR 1911, FOR A CITY IN CENTRAL NEW YORK.

(The remaining consumers are on meter schedule.)

No. of Consumers.	Amount Net per Year per Consumer.	No. of Consumers.	Amount Net per Year per Consumer.
1 110	$5.70	1	$41.16
236	8.56	1	43.08
742	9.50	1	35.44
36	10.45	2	34.50
36	11.40	1	33.88
73	12.36	1	47.80
203	13.32	2	40.84
32	14.28	3	42.12
242	15.20	4	45.60
66	15.80	19	26.60
66	16.16	1	48.00
35	17.12	1	22.60
209	18.04	2	25.96
48	19.00	1	37.36
7	19.60	4	26.90
118	19.96	1	28.50
37	20.88	1	33.84
34	21.88	1	40.20
46	22.16	2	50.00
33	22.80	1	66.50
31	23.76	1	68.40
11	24.08	1	75.00
15	24.72	3	80.00
6	25.00	1	60.00
66	25.32	4	100.00
29	28.16	1	86.48
15	29.12	1	85.00
28	30.04	1	75.36
11	31.36	1	79.80
13	27.56	1	250.00
9	32.32	1	85.80
8	33.32	2	300.00
5	34.30	1	57.47
5	36.12	1	340.00
3	37.08	2	71.24
5	38.00		
		Total 3 741	

TABLE 25.

CLASSIFICATION OF WATER CONSUMPTION, PENNSYLVANIA WATER COMPANY.
FEBRUARY 21, 1910.

No. of Taps.	Cu. Ft. per Year per Tap.	Total Quantity Cu. Ft. per Year.
6 038	3 344	20 190 000
1 384	5 500	7 612 000
1 795	7 000	12 565 000
1 288	10 000	12 880 000
375	14 000	5 250 000
143	18 000	2 574 000
167	25 000	4 175 000
78	35 000	2 730 000
109	50 000	5 450 000
53	70 000	3 710 000
31	90 000	2 790 000
38	110 000	4 180 000
11 499	7 314	84 106 000
Add:		
701	7 314	5 127 000
12 200	7 314	89 233 000

VARIATION IN RATE OF CONSUMPTION.

MONTHLY FLUCTUATION IN CONSUMPTION.

Mr. William S. Johnson, in an interesting paper entitled "Some New Facts Relating to the Effect of Meters on the Consumption of Water," published in the JOURNAL of this Association, Vol. 21, p. 109, gives the following data concerning the variation in consumption during different months of the year:

DIAGRAM SHOWING DAILY AVERAGE CONSUMP
DURING EACH WEEK OF THE

During this period the percentage of metered servi
the District from 972,080 to 1,086,690. The

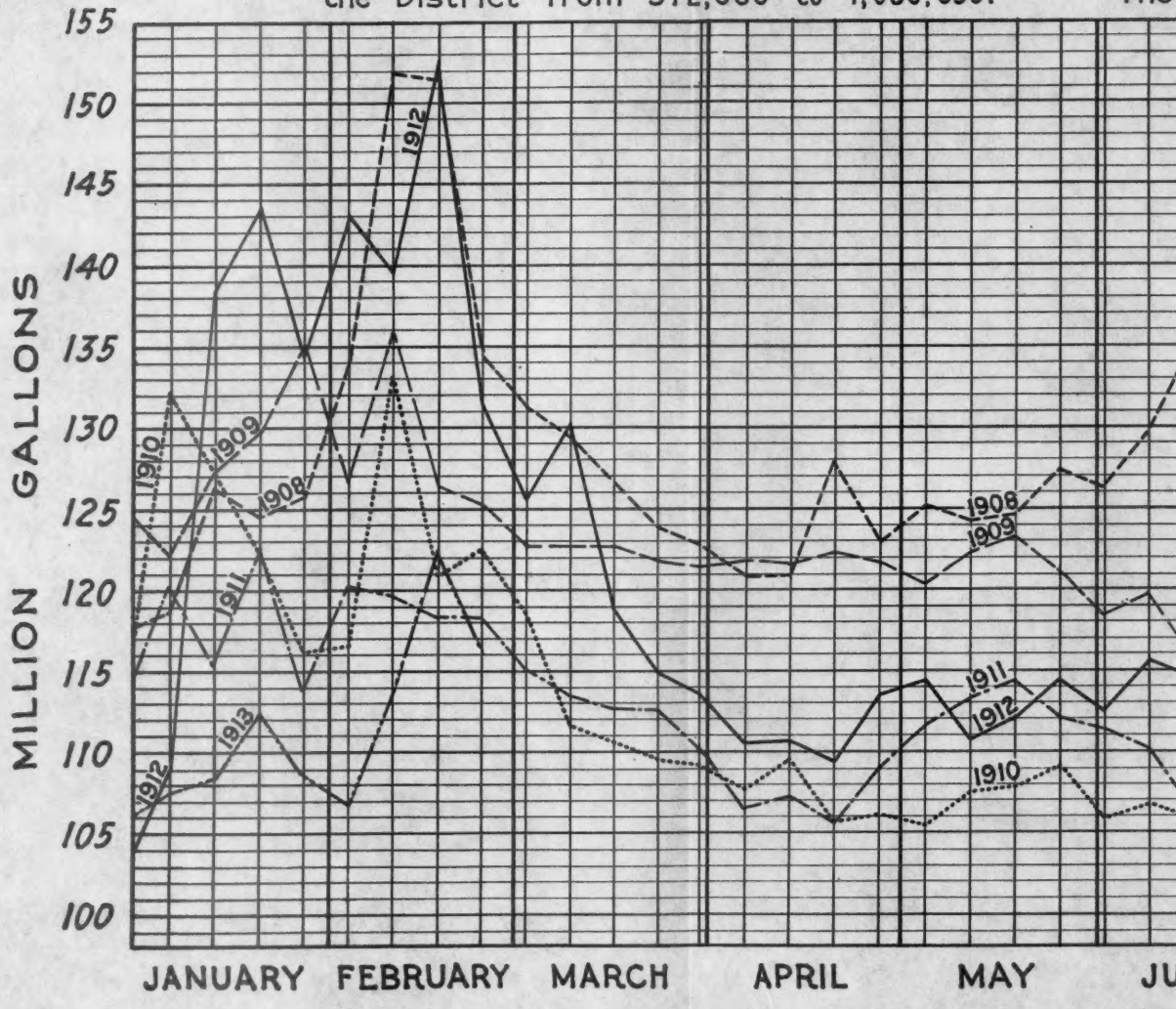


PLATE IX.
N. E. W. W. ASSOCIATION.
VOL. XXVII.
COMMITTEE ON
WATER CONSUMPTION.

MPTION OF WATER IN METROPOLITAN WATER DISTRICT
E YEARS 1908, 1909, 1910, 1911 AND 1912.

ervices was increased from 5.69 to 51.85 and the population of
The temperature during January and February 1912 was very low.

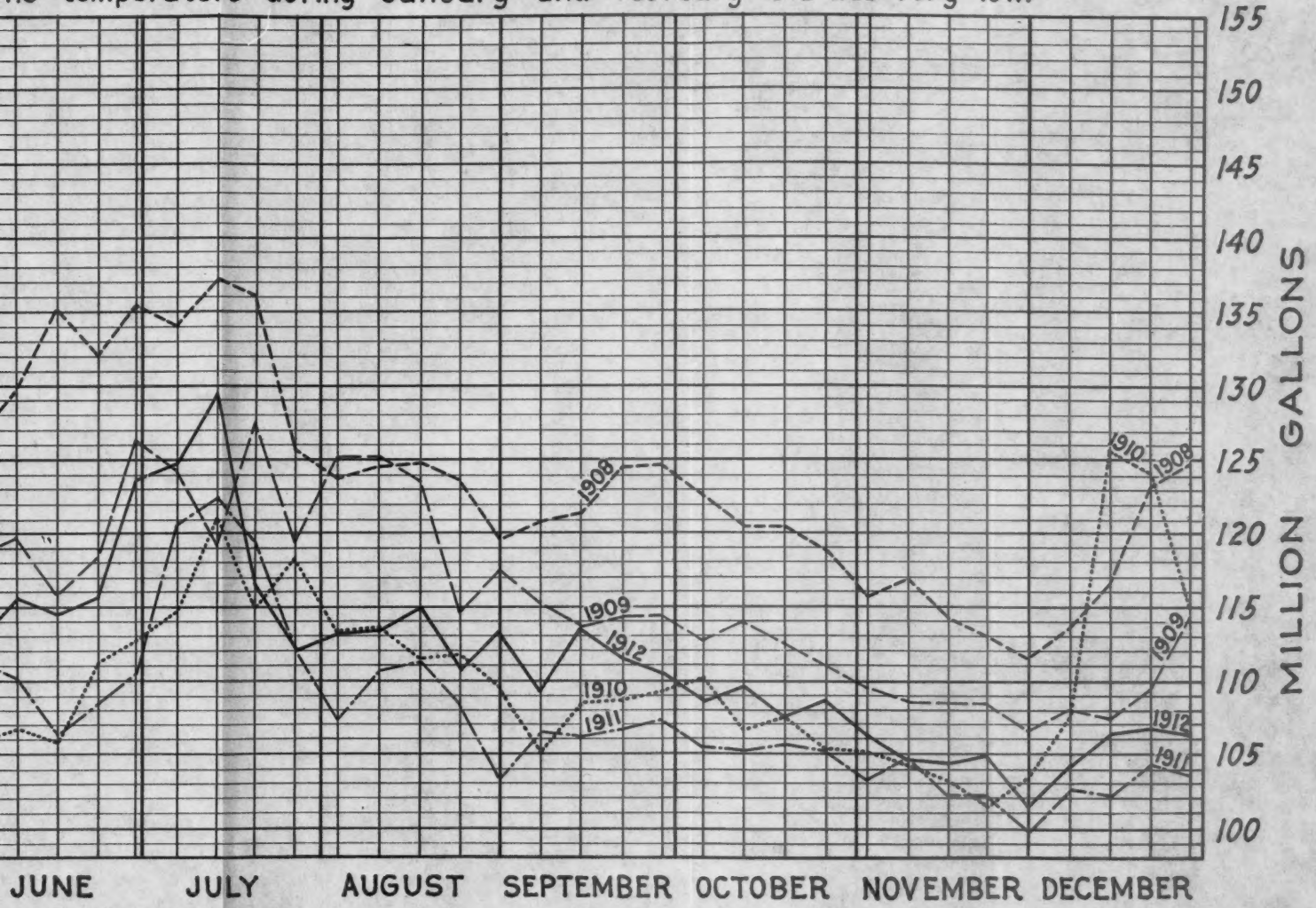


TABLE 26.

Consumption during Different Months.

(Table No. 6, p. 129, Vol. 21, Journal N. E. W. W. A., — Percentage which the consumption during each month is of the average monthly consumption, together with the average rainfall and temperature, Massachusetts.)

Average of Ten Years, 1896–1905.

Month.	Per Cent. of Average Consumption.	Rainfall. Inches.	Temperature. (Degrees fahr.)
January	90	3.68	23.9
February	92	3.98	24.3
March	89	4.77	34.9
April	87	3.86	45.6
May	100	3.18	57.2
June	113	3.60	64.5
July	124	3.85	70.7
August	118	3.97	67.6
September	108	4.12	61.4
October	96	3.35	50.9
November	90	3.34	38.7
December	92	3.74	27.7

(Table No. 8, p. 132, Vol. 21, Journal N. E. W. W. A., — Average consumption of water during each month in 1905 in cities and towns arranged in groups.)

Gallons per Person per Day.

Month.	Boston.	Metropolitan District.	Av. of 23 Suburban Cities and Towns.	Av. of 14 Large Manufacturing Cities.	Av. of 37 Small Cities and Towns.	Av. of 12 Summer Resorts.
January	165	137	77	70	48	67
February	175	147	85	74	53	75
March	152	127	77	69	50	65
April	140	117	73	65	46	65
May	144	121	79	68	52	89
June	146	123	79	70	53	109
July	151	131	88	72	58	150
August	148	127	79	69	56	131
September	147	126	75	65	50	101
October	145	124	73	65	47	74
November	144	122	70	64	46	61
December	153	129	71	64	45	65
Year	151	128	77	68	50	88

HOURLY AND WEEKLY FLUCTUATIONS IN CONSUMPTION.

The following diagrams, prepared by Metcalf & Eddy from data kindly furnished by the superintendents of the works stated, are of interest as showing the hourly and weekly fluctuation in consumption at Holyoke, Springfield, Boston, and Fall River, Mass.; Nashua, N. H.; Hartford, Conn.; Woonsocket, R. I.; and Peoria, Ill.

Further similar data are also contained in this report, in the diagrams relating to waste of water.

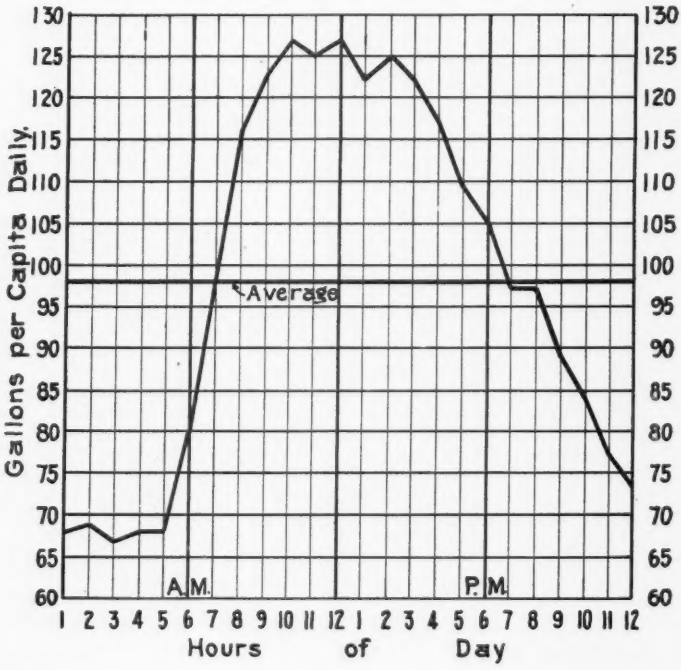


FIG. 4.

WATER CONSUMPTION IN HOLYOKE, MASS. HOURLY CONSUMPTION FOR AVERAGE DAY IN WEEK ENDING NOVEMBER 17, 1905. ESTIMATED POPULATION SUPPLIED, 51 000.

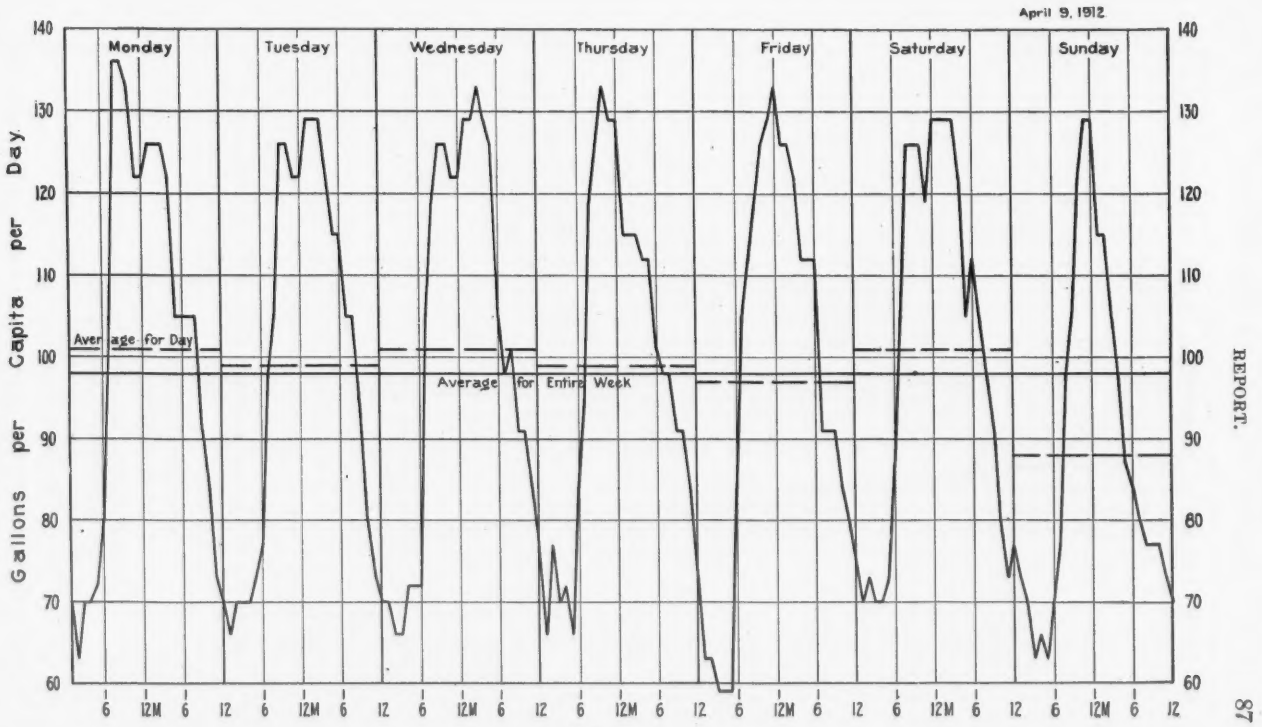


FIG. 5.

HOLYOKE, MASS. FLUCTUATIONS IN WATER CONSUMPTION DURING WEEK ENDING NOVEMBER 17, 1905.

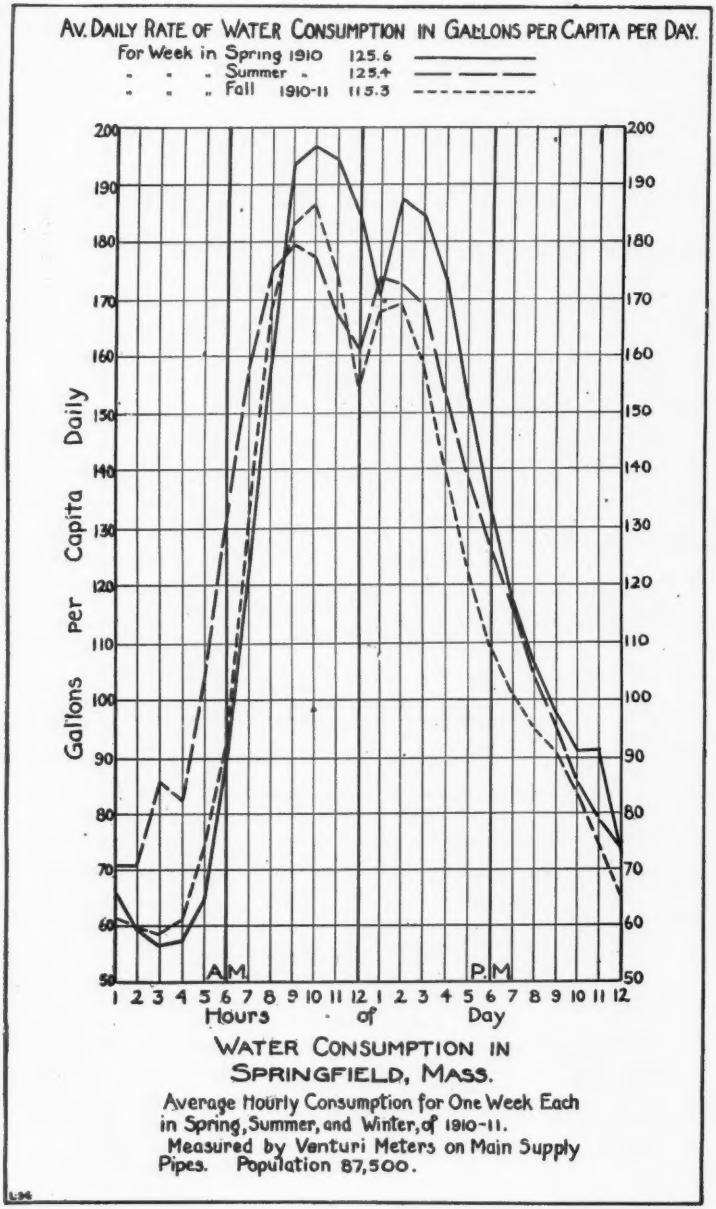

AV. DAILY RATE OF WATER CONSUMPTION IN GALLONS PER CAPITA PER DAY.
For Week in Spring 1910 125.6
" " " Summer " 125.4
" " " Fall 1910-11 115.3
Gallons per Capita Daily
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Hours of Day
WATER CONSUMPTION IN SPRINGFIELD, MASS.
Average Hourly Consumption for One Week Each in Spring, Summer, and Winter, of 1910-11.
Measured by Venturi Meters on Main Supply Pipes. Population 87,500.

FIG. 6.

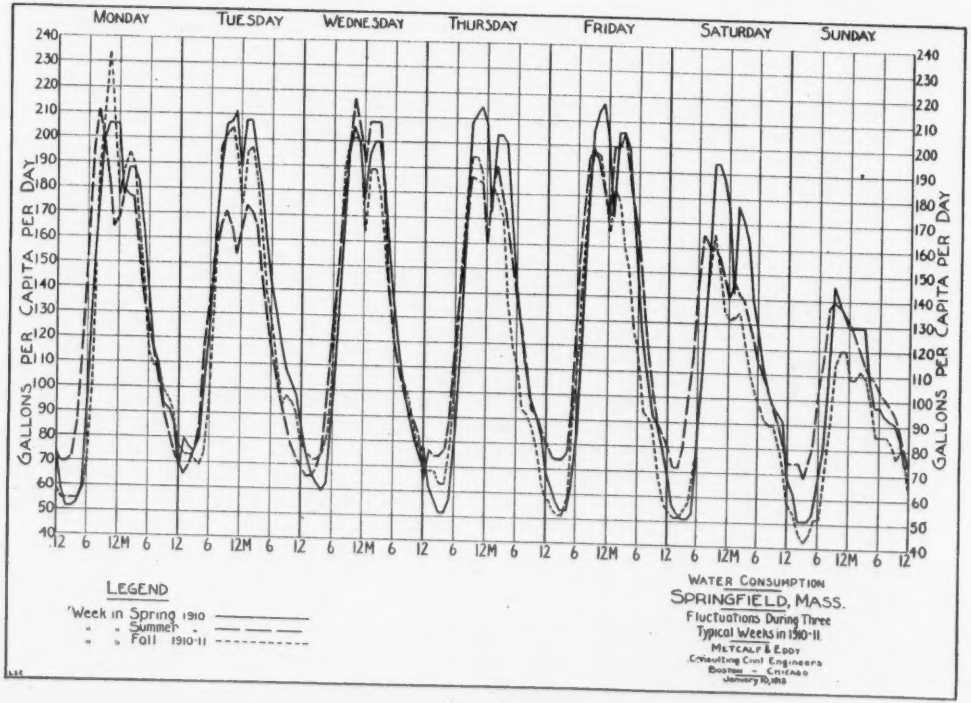

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
GALLONS PER CAPITA PER DAY
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12
LEGEND
Week in Spring 1910
" " Summer "
" " Fall 1910-11
WATER CONSUMPTION
SPRINGFIELD, MASS.
Fluctuations During Three
Typical Weeks in 1910-11.
METCALF & EDDY
Consulting Civil Engineers
Boston - Chicago
January 10, 1912

FIG. 7.

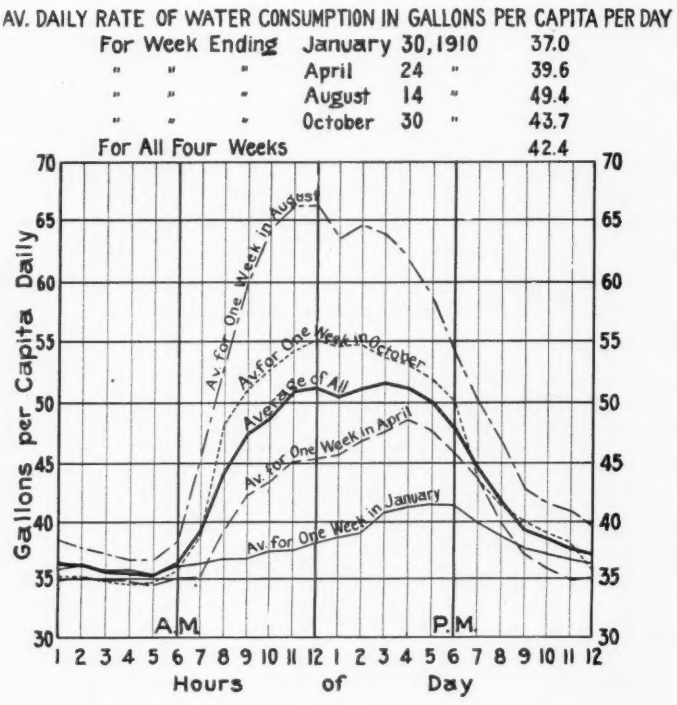

AV. DAILY RATE OF WATER CONSUMPTION IN GALLONS PER CAPITA PER DAY
For Week Ending January 30, 1910 37.0
" " " April 24 " 39.6
" " " August 14 " 49.4
" " " October 30 " 43.7
For All Four Weeks 42.4
Gallons per Capita Daily
Av. for One Week in August
Av. for One Week in October
Average of All
Av. for One Week in April
Av. for One Week in January
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Hours of Day

FIG. 8.

WATER CONSUMPTION IN FALL RIVER, MASS. AVERAGE HOURLY CONSUMPTION FOR ONE WEEK EACH IN WINTER, SPRING, SUMMER, AND AUTUMN, 1910. COMPUTED FROM PUMP RECORDS ADJUSTED FOR SLIP AND OVERFLOW FROM STANDPIPE. POPULATION, 119 295 (CENSUS).

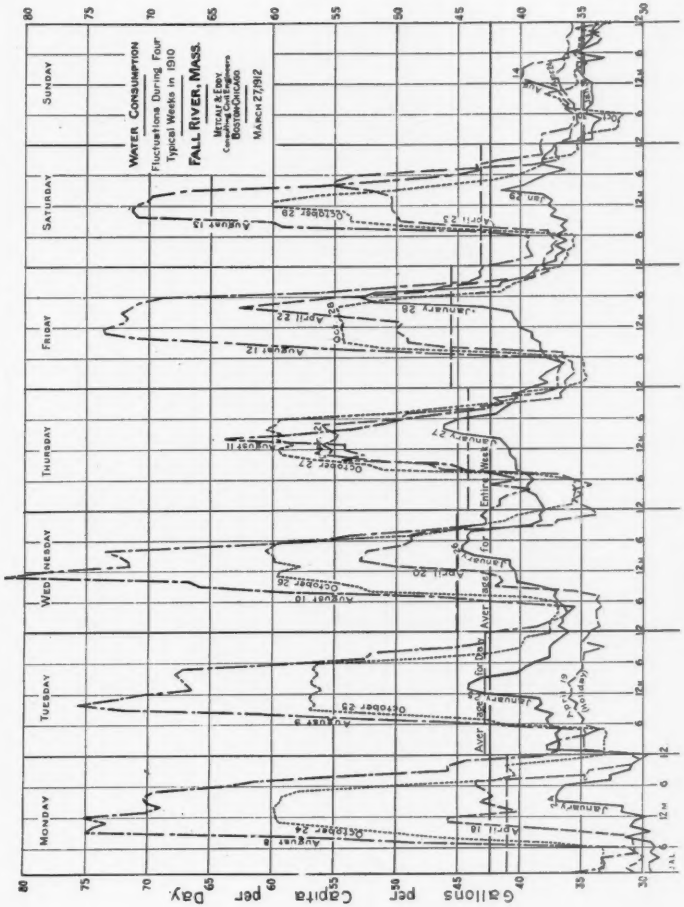

WATER CONSUMPTION
Fluctuations During Four Typical Weeks in 1910
FALL RIVER, MASS.
METCALF & EDDY
Consulting Civil Engineers
BOSTON CHICAGO
MARCH 27, 1912
Gallons per Capita per Day
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
August 8
October 24
August 9
October 25
August 10
October 26
August 11
October 27
August 12
October 28
January 25
April 16
January 26
April 17
January 27
April 18
January 28
April 19
January 29
April 20
January 30
April 21
January 31
April 22
Average for Entire Week
Average for Week Days
Average for Week Ends

FIG. 9.

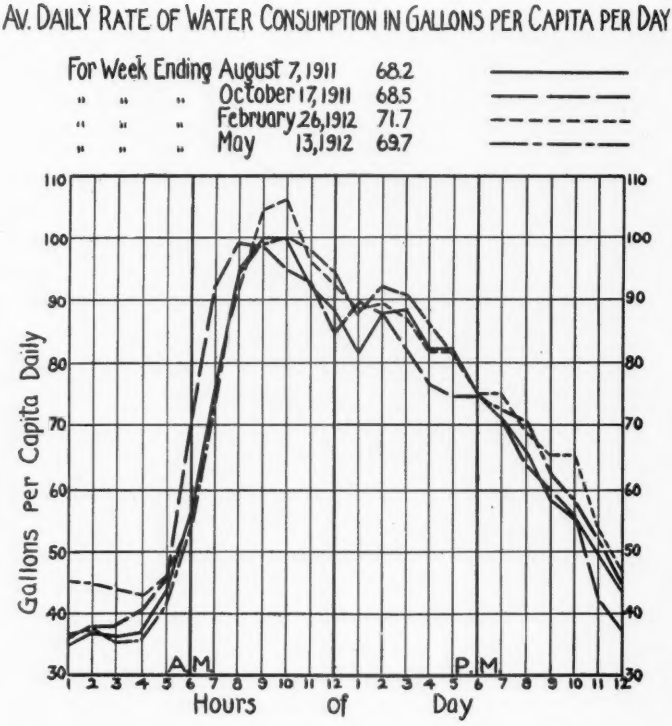

Av. Daily Rate of Water Consumption in Gallons per Capita per Day
For Week Ending August 7, 1911 68.2
" " " October 17, 1911 68.5
" " " February 26, 1912 71.7
" " " May 13, 1912 69.7
Gallons per Capita Daily
110
100
90
80
70
60
50
40
30
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Hours of Day

FIG. 10.

WATER CONSUMPTION IN HARTFORD, CONN. AVERAGE HOURLY CONSUMPTION FOR ONE WEEK EACH IN SUMMER, AUTUMN, WINTER, AND SPRING IN 1911–12, MEASURED BY VENTURI METER. POPULATION, 121 644.

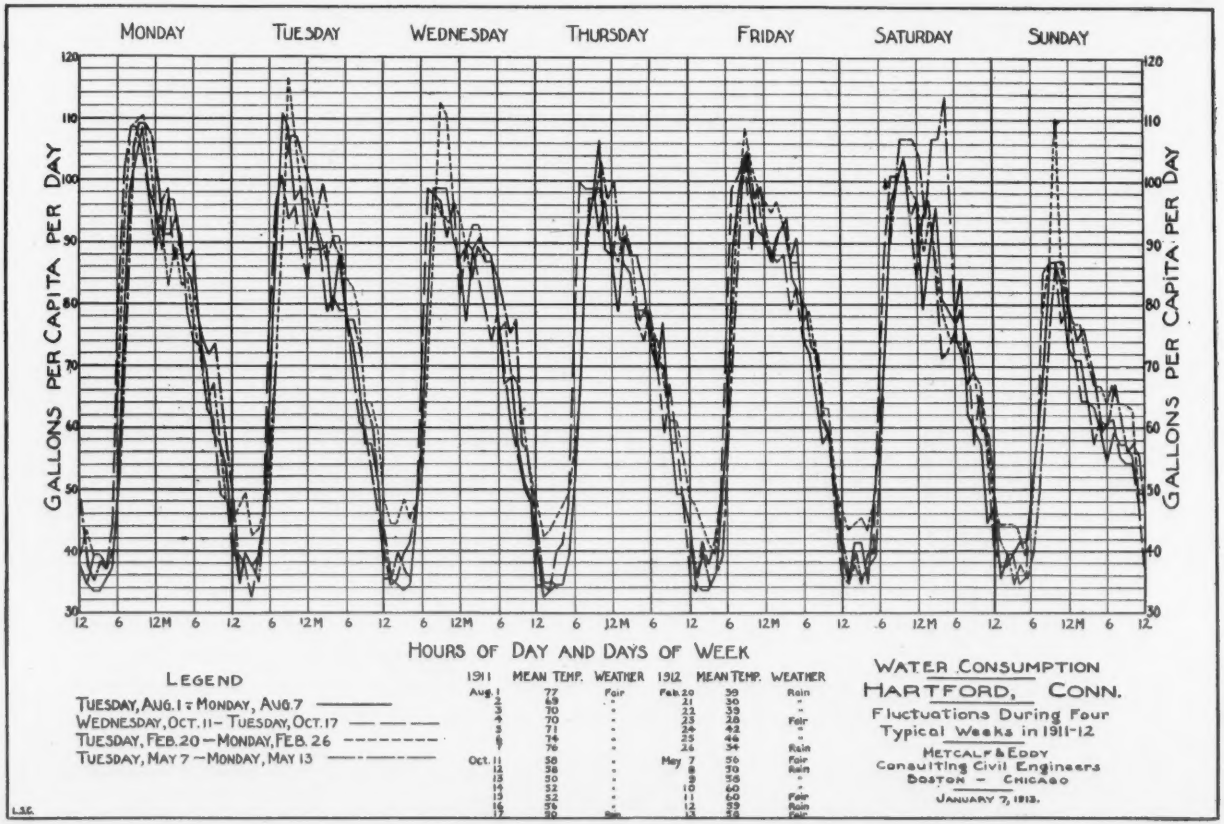

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
GALLONS PER CAPITA PER DAY
120
110
100
90
80
70
60
50
40
30
12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12
HOURS OF DAY AND DAYS OF WEEK
LEGEND
TUESDAY, AUG. 1 - MONDAY, AUG. 7
WEDNESDAY, OCT. 11 - TUESDAY, OCT. 17
TUESDAY, FEB. 20 - MONDAY, FEB. 26
TUESDAY, MAY 7 - MONDAY, MAY 13
1911 MEAN TEMP. WEATHER
Aug. 1 77 Fair
2 69 "
3 70 "
4 70 "
5 71 "
6 74 "
7 76 "
Oct. 11 58 "
12 58 "
13 50 "
14 52 "
15 52 "
16 56 "
17 50 Rain
1912 MEAN TEMP. WEATHER
Feb. 20 38 Rain
21 30 "
22 39 "
23 28 Fair
24 42 "
25 46 "
26 34 Rain
May 7 56 Fair
8 70 Rain
9 58 "
10 60 "
11 60 "
12 59 Rain
13 58 Fair
WATER CONSUMPTION
HARTFORD, CONN.
Fluctuations During Four Typical Weeks in 1911-12
METCALF & EDDY
Consulting Civil Engineers
BOSTON - CHICAGO
JANUARY 7, 1913.
L.S.C.

FIG. 11.

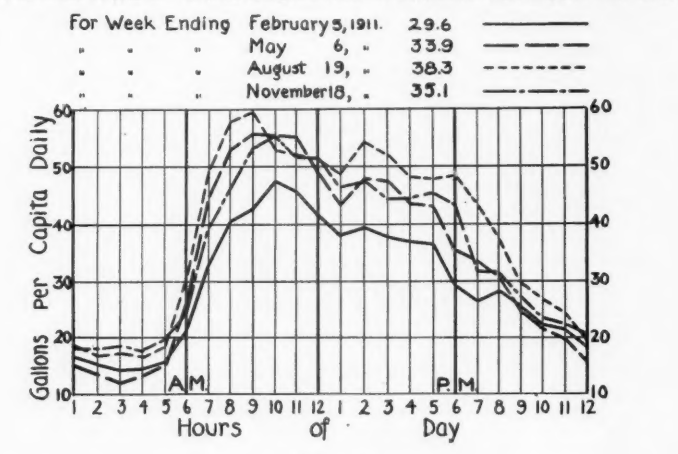

AV. DAILY RATE OF WATER CONSUMPTION IN GALLONS PER CAPITA PER DAY.
For Week Ending February 5, 1911. 29.6
" " " May 6, " 33.9
" " " August 19, " 38.3
" " " November 18, " 35.1
Gallons per Capita Daily
60
50
40
30
20
10
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Hours of Day

FIG. 12.

WATER CONSUMPTION IN WOONSOCKET, R. I. AVERAGE HOURLY CONSUMPTION FOR ONE WEEK EACH IN WINTER, SPRING, SUMMER, AND FALL OF 1911. MEASURED BY VENTURI METER IN PIPE LINE.

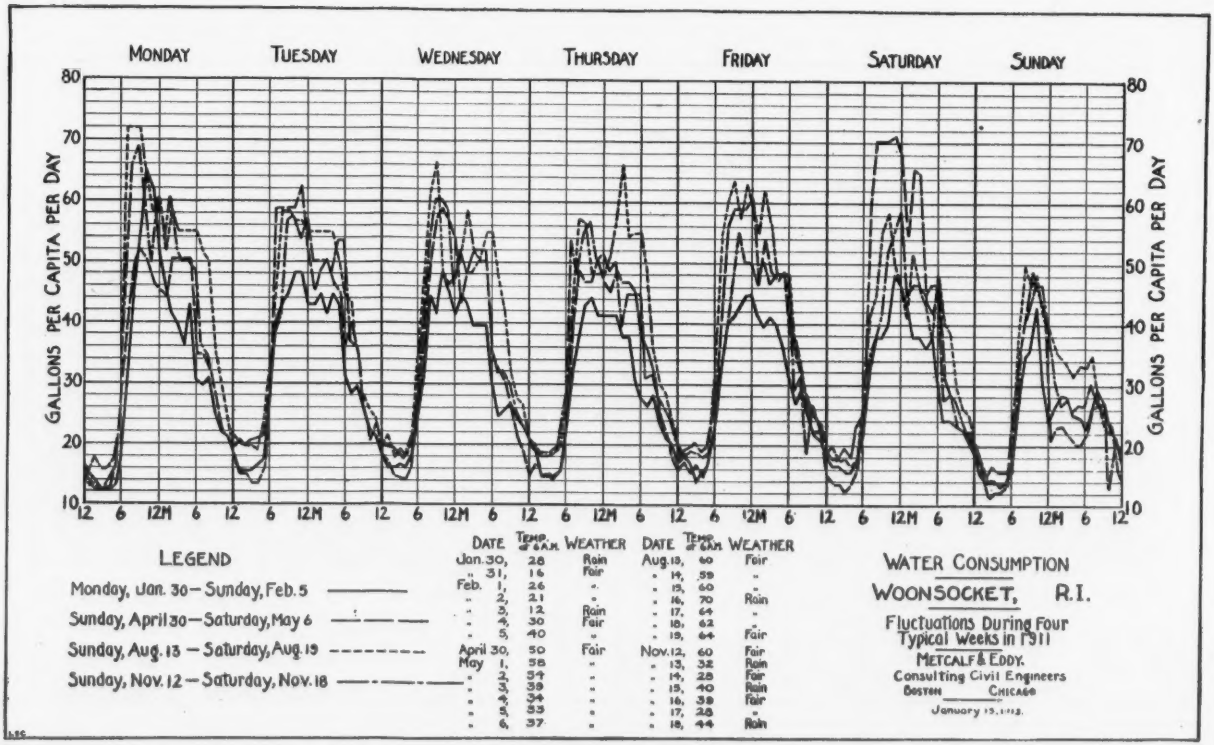

MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
GALLONS PER CAPITA PER DAY
80
70
60
50
40
30
20
10
12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12 6 12M 6 12
LEGEND
Monday, Jan. 30 — Sunday, Feb. 5
Sunday, April 30 — Saturday, May 6
Sunday, Aug. 13 — Saturday, Aug. 19
Sunday, Nov. 12 — Saturday, Nov. 18
DATE TEMP. 9 A.M. WEATHER
Jan. 30, 28 Rain
" 31, 16 Fair
Feb. 1, 26 "
" 2, 21 "
" 3, 12 Rain
" 4, 30 Fair
" 5, 40 "
April 30, 50 Fair
May 1, 58 "
" 2, 54 "
" 3, 38 "
" 4, 34 "
" 5, 33 "
" 6, 37 "
DATE TEMP. 9 A.M. WEATHER
Aug. 13, 60 Fair
" 14, 58 "
" 15, 60 "
" 16, 70 Rain
" 17, 64 "
" 18, 62 "
" 19, 64 Fair
Nov. 12, 60 Fair
" 13, 32 Rain
" 14, 28 Fair
" 15, 40 Rain
" 16, 38 Fair
" 17, 28 "
" 18, 44 Rain
WATER CONSUMPTION
WOONSOCKET, R.I.
Fluctuations During Four Typical Weeks in 1911
METCALF & EDDY.
Consulting Civil Engineers
BOSTON CHICAGO
January 15, 1913.

FIG. 13.

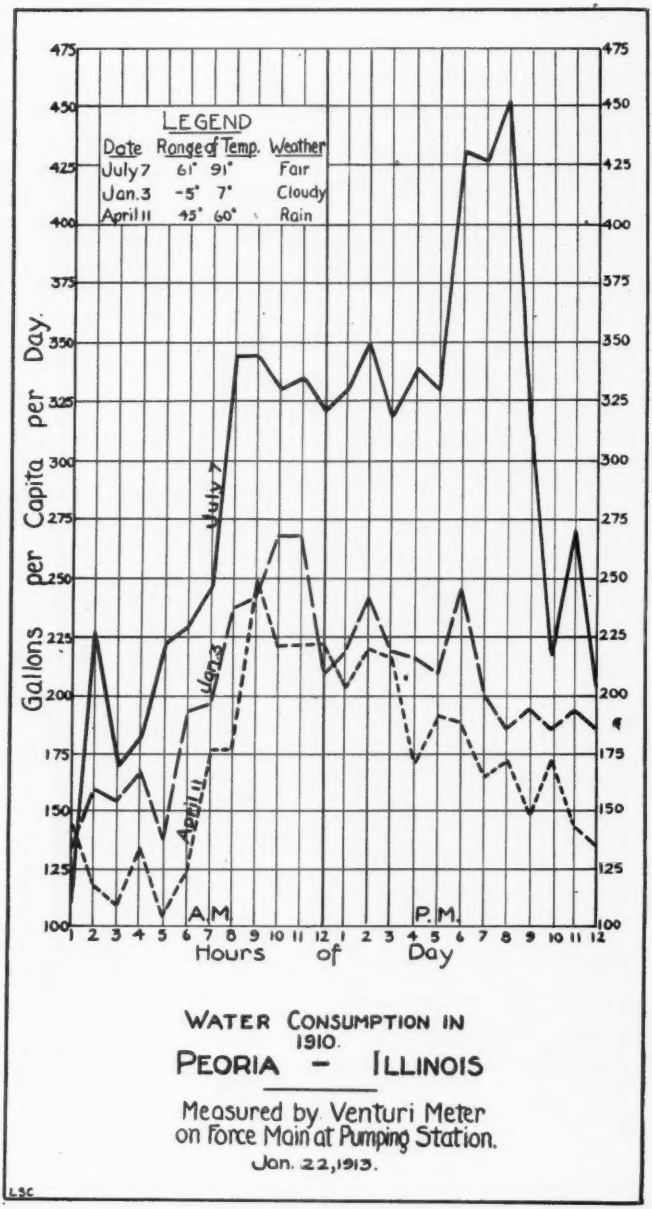

LEGEND
Date Range of Temp. Weather
July 7 61° 91° Fair
Jan. 3 -5° 7° Cloudy
April 11 45° 60° Rain
Gallons per Capita per Day.
July 7
Jan 3
April 11
A.M.
P.M.
Hours of Day
WATER CONSUMPTION IN 1910.
PEORIA - ILLINOIS
Measured by Venturi Meter on Force Main at Pumping Station.
Jan. 22, 1913.
LSC

FIG. 14.

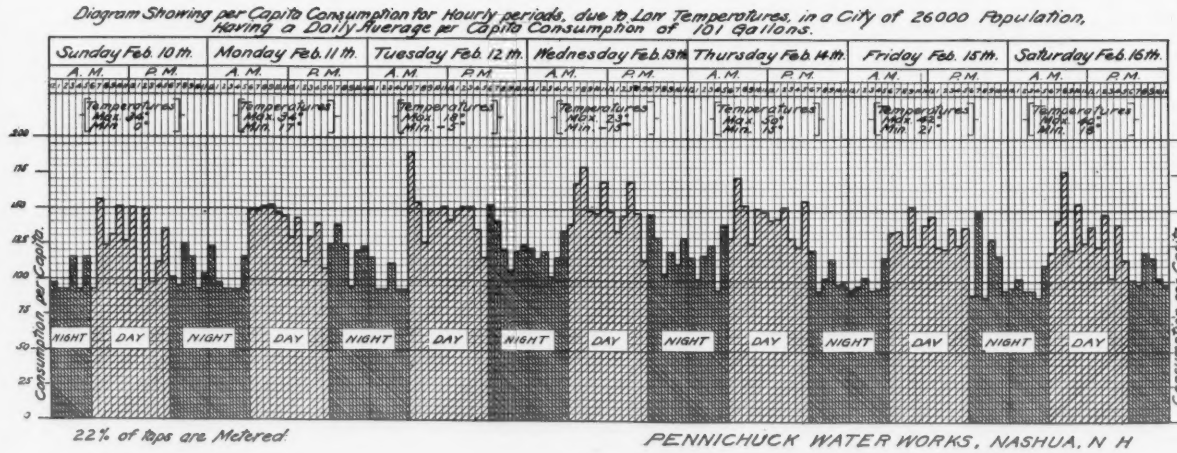


Diagram Showing per Capita Consumption for Hourly periods, due to Low Temperatures, in a City of 26000 Population, Having a Daily Average per Capita Consumption of 101 Gallons.
Sunday Feb. 10th.
Monday Feb. 11th.
Tuesday Feb. 12th.
Wednesday Feb. 13th.
Thursday Feb. 14th.
Friday Feb. 15th.
Saturday Feb. 16th.
A. M.
P. M.
Temperatures Max. 30° Min. 0°
Temperatures Max. 54° Min. 17°
Temperatures Max. 10° Min. -5°
Temperatures Max. 23° Min. -13°
Temperatures Max. 40° Min. 15°
Temperatures Max. 48° Min. 21°
Temperatures Max. 42° Min. 16°
NIGHT
DAY
Consumption per Cap.ta
22% of Reps are Metered
PENNICHUCK WATER WORKS, NASHUA, N H

FIG. 15.

TABLE 27.

RECORDS OF MAXIMUM WATER CONSUMPTION FOR MASSACHUSETTS CITIES AND TOWNS, 1910.

(By courtesy of X. H. Goodnough.)

City or Town.	Population.	Average Daily Consumption per Person.	Max. Monthly Consumption.		Max. Weekly Consumption.		Max. Daily Consumption.	
			Gal. per Person per Day.	Per Cent. of Average for Year.	Gal. per Person per Day.	Per Cent. of Average for Year.	Gal. per Person per Day.	Per Cent. of Average for Year.
Abington and Rockland	12 383	45	63	137	70	151	90	197
Amesbury	9 894	44	50	114	51	116	68	155
Andover	7 301	86	99	115	...	...	162	189
Attleborough	16 215	54	62	115	63	116	91	169
Avon	2 013	36	55	153	72	200	102	283
Ayer	2 797	50	64	128	72	144	172	342
Beverly	18 650	91	146	160	191	210	224	246
Braintree	8 066	81	87	107	93	115	108	133
Bridgewater and E. Bridgewater	11 051	22	27	123	29	132	39	177
Brockton	56 878	39	45	115	55	141	69	177
Brookline	27 792	89	103	116	117	132	128	177
Cambridge	104 839	100	106	106	111	111	119	119
Canton	4 797	61	75	123	84	138	97	159
Danvers and Middleton	10 536	89	108	121	136	153	158	178
Dedham	9 284	129	153	119	163	128	182	141
Easton	5 139	24	28	117	38	158	63	263
Fall River	119 295	44	47	107	50	114	54	123
Foxborough	3 863	50	51	102	59	118	75	150
Framingham	12 948	48	58	121	65	137	86	179
Franklin	5 641	61	88	144	96	158	127	208
Gardner	14 699	44	49	111	55	125	108	246
Gloucester	24 398	55	96	156	114	207	130	237
Grafton	5 705	18	22	122	24	133	32	178
Hudson	6 743	49	60	123	65	133	...	...
Ipswich	5 777	42	60	143	84	200	106	253
Lawrence	85 892	45	51	113	60	133	60	133

Lowell	106 294	51	57	112	66	129	75	147
Lynn and Saugus	97 383	72	79	110	87	121	108	150
Manchester	2 673	120	261	217	327	271	363	302
Mansfield	5 183	75	97	129	103	137	276	368
Marblehead	7 338	79	147	186	169	214	187	237
Marlborough	14 579	37	42	114	59	159	80	190
Maynard	6 390	36	39	108	47	130	60	167
Methuen	11 448	38	54	142	67	176	69	182
Middleborough	8 214	42	53	126	65	155	90	214
Milford and Hopedale	15 243	51	60	118	64	125	71	139
Montague and Erving	8 014	66	75	114	70	106	153	232
Nantucket	2 962	67	128	191	154	230	176	263
Natick	9 866	57	70	123	82	144	170	298
Needham	5 026	66	88	133	98	148	119	180
New Bedford	96 652	81	88	109	98	121	106	131
Newburyport	14 949	68	83	122	94	138	121	178
Newton	39 806	63	74	118	82	130	95	150
North Andover	5 529	40	53	132	64	160	78	195
North Attleborough	9 562	52	73	140	82	158	95	183
North Brookfield	3 075	66	81	123	112	170	213	319
Norwood	8 014	63	86	136	86	136	132	211
Orange	5 282	26	34	131	41	158	62	182
Peabody	15 721	168	198	118	182	108	270	161
Plymouth	12 141	103	131	127	140	136	171	166
Provincetown	4 369	38	69	182	77	203	93	245
Randolph and Holbrook	7 117	74	120	162	140	189	175	237
Reading	5 818	35	52	149	60	172	66	189

TABLE 27 (*Continued*).

RECORDS OF MAXIMUM WATER CONSUMPTION FOR MASSACHUSETTS CITIES AND TOWNS, 1910.

City or Town.	Population.	Average Daily Consumption per Person.	Max. Monthly Consumption.		Max. Weekly Consumption.		Max. Daily Consumption.	
			Gal. per Person per Day.	Per Cent. of Average for Year.	Gal. per Person per Day.	Per Cent. of Average for Year.	Gal. per Person per Day.	Per Cent. of Average for Year.
Rockport	4 211	72	148	205	196	272	212	295
Salem	43 697	90	101	112	103	114	133	148
Sharon	2 310	57	97	170	120	210	137	240
Stoughton	6 316	35	43	123	58	166	75	214
Taunton	34 259	63	70	111	74	118	87	138
Wakefield	11 404	61	85	139	107	175	127	208
Walpole	4 892	102	119	117	149	146	252	247
Waltham	27 834	88	95	108	98	111	108	123
Webster	11 509	38	49	129	53	139	72	189
Wellesley	5 413	61	68	111	79	129	112	184
Whitman	7 292	29	42	145	44	152	...	...
Winchendon	5 678	30	35	117	40	133	45	150
Woburn	15 308	139	172	124	190	137	232	167
Worcester	145 986	74	85	115	...	...	103	139
Average		63	81	128	93	147	123	198

MAXIMUM RATE OF CONSUMPTION.

Table 27 gives the maximum rate of water consumption for Massachusetts cities and towns, for the year 1910, kindly furnished by Mr. X. H. Goodnough.

Similar data are given in Table 28, relating to Worcester and Providence, kindly furnished by Mr. F. A. McClure and Mr. Otis F. Clapp.

TABLE 28.

MAXIMUM RATE OF WATER CONSUMPTION FOR WORCESTER AND PROVIDENCE.

YEAR.	WORCESTER, MASS.		PROVIDENCE, R. I.	
	Per Cent. which Max. Monthly Consumption is of Average for Year.	Per Cent. which Max. Daily Consumption is of Average for Year.	Per Cent. which Max. Monthly Consumption is of Average for Year.	Per Cent. which Max. Daily Consumption is of Average for Year.
(1)	(2)	(3)	(4)	(5)
1897			107.7	139.7
1898			112.4	143.7
1899			115.2	139.7
1900	113.3	169.	121.8	148.0
1901	114.5	137.4	114.1	147.0
1902	111.8	141.4	113.2	135.5
1903	109.8	135.1	108.2	128.3
1904	105.2	126.2	106.8	138.3
1905	105.8	117.2	114.7	137.5
1906	103.5	130.	106.6	120.
1907	110.9	128.	116.1	137.3
1908	105.5	124.1	109.6	139.3
1909	111.5	137.	119.	136.7
1910	115.24	140.70	112.2	138.5
1911	109.08	127.10		

Mr. George G. Earl, superintendent of the New Orleans water works, reports that their new plant served about 250 000 population in 1911, the per capita daily consumption being about as follows:

Average = 64 gal.
Maximum = 100 gal., or 156 per cent. of the average.
Minimum = 32 gal., or 50 per cent. of the average.

Industrial Uses.

Mr. Dexter Brackett, chief engineer of the Metropolitan Water Works, of Boston, reports the following trade uses of water in the Metropolitan Water District. Table 29 gives the water supplied through meters (only, not by flat rates) for domestic, manufacturing and trade, public and miscellaneous purposes in the year 1908; Table 3, p. 38, the per capita consumption and per cent. of services metered in the cities and towns supplied from the Metropolitan Water Works, 1904 to 1912; Table 30, the water supplied, through meters only, for manufacturing, mechanical, and trade purposes during the year 1908; Table 31, similar figures for the year 1902; Table 32, the detailed data for the year 1908, for a number of the cities in the Metropolitan District, from which the summarized data previously alluded to have been prepared.

TABLE 29.

WATER SUPPLIED THROUGH METERS FOR DOMESTIC, MANUFACTURING AND TRADE, PUBLIC AND MISCELLANEOUS PURPOSES IN THE METROPOLITAN WATER DISTRICT DURING THE YEAR 1908.

NOTE. These quantities are exclusive of water used on flat rates.

(By courtesy of Mr. Dexter Brackett.)

City or Town.	Estimated Population, July 1, 1908.	Miles of Pipe, Jan. 1, 1908.	Number of Services, Jan. 1, 1908.	Per Cent. of Services Metered, Jan. 1, 1908.	Estimated Population on Meter Service.	Domestic per Cap. on Meter Population.	Per Capita Consumption on Total Population.					Total per Cap. Delivered to Mains.	Per Cent. of Total Accounted For.	City or Town.
							Domestic.	Mfg. and Mech.	Public.	Miscellan's.	Total.			
Boston	643 810	745.32	91 142	5.69	53 799	33.0	2.92	27.74	2.05	1.01	33.72	153	22.06	Boston
Chelsea*	32 190	40.32	4 000	33.93	13 937	26.1	11.31	20.84	3.38	0.14	35.67	89	40.01	Chelsea
Everett	31 930	45.02	5 161	2.25	395	33.1	0.41	18.07	0.19	0.01	18.68	83	22.62	Everett
Malden	42 140	83.51	7 055	96.10	37 994	17.6	15.92	6.56	3.45	0.63	26.56	44	59.90	Malden
Medford	21 920	53.73	4 378	13.29	3 559	24.8	4.13	6.55	3.90	1.10	15.68	94	16.62	Medford
Melrose	15 210	46.50	3 429	30.85	4 234	30.2	8.41	2.08	....	1.00	11.49	89	12.92	Melrose
Quincy	31 010	95.38	6 091	24.30	8 391	25.6	6.93	19.12	4.42	0.16	30.63	97	30.99	Quincy
Somerville	74 400	86.76	11 662	29.55	26 234	25.6	9.07	16.63	2.44	0.34	28.48	89	32.16	Somerville
Arlington	10 650	36.23	1 929	43.29	4 404	31.9	13.65	10.56	1.88	0.31	26.40	91	28.95	Arlington
Belmont	5 120	20.28	792	100.00	4 402	20.5	17.63	13.01	2.70	6.00	39.34	71	55.12	Belmont
Lexington	4 780	19.45	730	10.96	373	38.4	3.00	2.08	....	0.46	5.54	77	8.05	Lexington
Milton	7 610	39.53	1 285	100.00	6 000	26.7	21.25	3.07	5.78	0.51	30.61	44	70.24	Milton
Nahant	1 090	16.34	410	21.95	404	68.6	25.42	9.09	2.84	3.00	40.35	70	31.39	Nahant
Revere	16 240	37.77	2 927	5.57	938	36.6	2.11	1.89	0.48	1.08	5.56	78	6.99	Revere
Stoneham	6 820	22.07	1 331	2.25	....	....	....	6.09	....	....	6.09	92	6.63	Stoneham
Swampscott	5 830	18.95	1 307	68.25	2 871	34.7	17.17	3.88	1.31	0.06	22.42	76	25.66	Swampscott
Watertown	12 300	32.28	1 886	100.00	11 299	16.7	15.36	8.92	10.54	0.51	35.33	60	59.36	Watertown
Winthrop	9 030	25.35	2 074	3.38	488	35.3	1.91	1.11	2.89	0.07	5.98	103	5.82	Winthrop
Totals	972 080	1 464.79	147 589	17.71	179 722	26.8	4.95	22.45	2.30	0.84	30.54	129	23.74	Totals

* 1909 used on account of fire in April, 1908.

TABLE

WATER SUPPLIED THROUGH METERS IN THE METROPOLITAN
(By courtesy of

	Boston.	Somerville.	Malden.	Chelsea.*	Everett.	Quincy.	Medford.
Population	643 810	74 400	42 140	32 190	31 930	31 010	21 920
Per cent. services metered	5.69	29.55	96.10	33.93	2.25	24.30	13.29
Per cent. population supplied through meters	8.36	35.26	90.16	43.30	1.24	27.06	16.24
Purposes for Which Used.							
Manufacturing, Mechanical and Trade:							
Bakeries	.079	.033	.015	.225	...	...	...
Breweries and bottling	.875	.078	...	...	.086	...	...
Coal dealers	...	.025	.084	.240	...	...	...
Contractors	.011	.029	.029	...	.088	...	...
Dye works	.024	.174	.050	.066	.018	...	.627
Electric companies	.809	.014	1.242	.064	...	.744	...
Elevators and motors	.586	.065	.119	.009	.011	.010	...
Factories and machine shops	1.833	1.364	1.069	4.812	2.279	11.398	.398
Farms and greenhouses	.037	.028	.089	...	.069	.275	.105
Gas works	.488	...	.955	.011	11.436	.119	...
Hotels	3.059	.174	.052	.104	.063	.147	.080
Iron works	.211	.004	...	.804	...	...	.119
Laundries	.656	.456	.395	.975	.467	.333	.144
Milk depots and creameries	.113	...	...	...	...	...	...
Miscellaneous	.441	...	.022	...	...	.066	...
Offices and stores	6.728	.722	1.678	.922	.224	.955	.480
Oils and chemicals	.041	.026	.234	.029	3.127	...	2.458
Railways	8.439	5.573	.160	3.479	.061	2.726	1.586
Restaurants and saloons	.378	...	...	.297	...	...	...
Rubber works	.052	...	.207	7.769	...	...	...
Shipping, wharves, etc	.918	...	.003	.638	...	.053	...
Slaughtering	.106	7.209	...	...	...	...	...
Stables	.718	.654	.151	.395	.141	.115	.263
Stone works	.089	...	.004	...	...	2.181	.296
Sugar refineries	1.045	...	...	...	...	...	...
Totals	27.736	16.628	6.558	20.839	18.070	19.122	6.556
Domestic	†2.924	9.070	15.924	11.311	.409	6.927	4.132
Public	†2.050	2.439	3.448	3.381	.189	4.421	3.898
Miscellaneous	†1.005	.348	.632	.139	.011	.163	1.096
Total metered to consumers	33.715	28.485	26.562	35.670	18.679	30.633	15.682
Total supplied through Venturi meters	153	89	44	89	83	97	94

* Year 1909, used on account of conditions following great fire in April, 1908.

† For further details see tabulations on pages 107–115 and 123–131.

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DISTRICT DURING THE YEAR 1908. (GALLONS PER CAPITA.)
Mr. Dexter Brackett.)

Melrose.	Revere.	Water-town.	Arling-ton.	Winthrop.	Milton.	Stone-ham.	Swamp-scott.	Lexing-ton.	Bel-mont.	Nahant.
15 210	16 240	12 300	10 650	9 030	7 610	6 820	5 830	4 780	5 120	1 090
30.85	5.57	100.00	43.29	3.38	100.00	2.25	68.25	10.96	100.00	21.95
27.84	5.78	91.86	41.35	5.40	78.84	...	49.25	7.80	85.98	37.06
.042	.121	...	.047	...	.113	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...
...	...	.020	...	...	.029	...	...	...	.063	...
...	.039	...	...	...	...	...	...	...	...	...
...	...	.119	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...
.024	.010	...	...	.285	.041	...	1.514	...	...	...
.269	.058	5.224	.435	...	.355	3.548	...	...	...	...
.089	.097	1.958	7.674	.266	1.102	.231	1.157	1.001	11.767	...
...	.721	.123	.584	...	...	...	...	.034	...	...
.168	.035	.024	.077	.312	.057	...	.696	...	.223	.761
...	...	...	...	...	...	...	...	...	...	...
.308	.357	.099	...	.047	.187	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	.020	...
.494	.064	.835	.606	.111	.488	...	.071	...	.641	...
.007	...	...	.455	...	...	.105	...	...	...	...
.221	.341	.213	.413	.086	.063	1.965	...	1.040	.053	...
...	...	.024	...	...	...	...	...	...	...	...
.011	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	5.954
...	...	.049	...	...	...	...	...	...	...	...
.444	.048	.236	.267	...	.635	.239	.443	...	.245	2.371
...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...
2.077	1.891	8.924	10.558	1.107	3.070	6.088	3.881	2.075	13.012	9.086
8.413	2.112	15.355	13.653	1.907	21.248	...	17.165	3.000	17.631	25.424
...	.476	10.537	1.881	2.897	5.784	...	1.310	...	2.696	2.841
.996	1.085	.510	.304	.070	.506	...	.060	.462	6.003	3.002
11.486	5.564	35.326	26.396	5.981	30.608	6.088	22.416	5.537	39.342	40.353
89	78	60	91	103	44	92	76	77	71	70

TABLE 31.

WATER SUPPLIED THROUGH METERS FOR MANUFACTURING, MECHANICAL, AND TRADE PURPOSES, DURING THE YEAR 1902.

(From "Consumption and Waste of Water," by D. Brackett, JOURNAL N. E. W. W. A., Vol. 18, p. 120, 1904.)

(Gallons per Capita per Day.)

	Boston.	Somerville.	Chelsea.	Malden.	Everett.	Quincy.	Medford.	Melrose.	Revere.	Watertown.	Arlington.	Milton.	Winthrop.	Stoneham.	Belmont.	Lexington.	Nahant.	Swampscott.	Metropolitan District.
Bakeries	.07	.06	.18	....	.04	....	....	.03	....	....	....	....	....	....	....	....	....	....	.06
Breweries and bottling	.96	.10	.....	.....	.04	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.65
Electric companies	1.73	.62	.....	1.40	.....	.31	.....	.....	1.42	.....	.....	.....	.....	.....	.....	.58	.....	.....	1.29
Elevators and motors	1.70	.09	.04	.08	.02	....	.08	.07	.01	.....	.....	.04	.03	....	.03	.....	.....	.....	1.16
Factories and machine shops	2.10	.73	6.15	.85	.37	2.03	.48	.19	....	1.91	.09	.11	....	1.74	.....	.....	.....	.....	1.86
Farms and greenhouses	.04	.02	.....	.04	.....	.02	.02	.16	.10	1.06	4.12	.01	....	.23	4.76	.....	.....	.....	.12
Gas works	.31	.....	.05	.11	13.46	.....	.....	.....	.....	.....	.23	.....	.....	.....	.....	.28	.....	.....	.63
Hotels	2.70	.07	.13	.08	.....	.06	.08	.16	.16	....	.18	.....	.....	.....	.....	.....	.....	.....	1.83
Iron works	.29	.01	.35	....	1.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.25
Laundries	.41	.....	.12	.01	.05	....	.29	.08	.....	.....	.....	.02	.....	.....	.....	.....	.....	.....	.29
Offices and stores	5.12	.39	.12	.70	.23	.28	.63	.19	....	.64	.41	.07	.....	.....	.03	.....	.....	.....	3.53
Oil and chemicals	.12	.16	.06	.06	2.61	....	.68	.04	.....	.....	.02	.....	.....	.....	.....	.....	.....	.....	.19
Railways	5.62	5.63	2.62	.04	.04	....	1.03	.17	....	.66	.67	.01	....	1.17	.19	1.67	....	....	4.35
Restaurants and saloons	.85	.....	.....	.....	.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.10	....	.57
Shipping	.77	.10	1.25	.06	.....	.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.27	....	.57
Slaughtering	.09	5.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.46
Stables	.59	.48	1.27	.15	.19	.01	.15	.45	.....	.....	.....	.36	....	.18	.05	....	1.21	....	.51
Sugar refineries	1.12	.....	.....	.....	.....	2.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.82
Miscellaneous	.30	.11	.01	.35	.22	1.58	.45	....	.19	....	.38	4.07	.14	....	....	....	....	....	.33
Totals	24.90	13.98	12.38	3.93	18.61	6.72	3.89	1.54	1.88	4.27	6.11	4.69	.17	3.34	5.06	2.52	1.58	....	19.47

TABLE 32.

WATER SUPPLIED BY METER (ONLY) FOR MANUFACTURING, MECHANICAL AND TRADE USES, IN THE METROPOLITAN WATER DISTRICT.

(By courtesy of Mr. Dexter Brackett.)

Boston, 1908.

(Population, 643 810.)

Manufacturing, Mechanical, and Trade.

		Number.	Gallons.	Per Capita per Day.
Bakeries		24	18 517 100	.079
Breweries and bottling		62		
Massachusetts Breweries Co.	44 805 200			
Others	161 351 000			
			206 156 200	.875
Cold storage plants		3	55 194 900	.234
Contractors		2	2 685 300	.011
Creameries		1	3 986 800	.017
Dye works		7	5 565 400	.024
Electric companies (Edison Elec. Ill. Co.)		1	190 687 600	.809
Elevators and motors		340	138 178 100	.586
Engines and boilers		8	3 111 700	.013
Factories and machine shops		285	428 716 200	1.820
Farms and greenhouses		11	8 617 000	.037
Fish packing houses		33	19 253 500	.082
Gas works (Boston Consolidated Gas Co.)		1	114 900 300	.488
Hotels		166		
Touraine	46 076 800			
Parker House	37 549 600			
United States	36 210 700			
Adams House	32 687 600			
Others	568 195 800			
			720 720 500	3.059
Iron works		34	49 779 400	.211
Laundries		71	154 505 900	.656
Milk depots		2	22 679 400	.096
Offices and stores			1 585 399 500	6.728
Oils and chemicals		8	9 731 500	.041

		Number.	Gallons.	Per Capita per Day.
Railways:				
Boston & Maine	459 997 600			
Boston Elevated	614 609 200			
Boston, Revere Beach & Lynn	45 740 200			
Boston Terminal Co	125 866 000			
N. Y. Central & Hudson River,	261 904 700			
N. Y., N. H. & H	477 919 600			
Old Colony St. Ry	381 500			
Union Freight R. R	2 012 100			
			1 988 430 900	8.439
Restaurants		48	42 395 400	.180
Rubber works		4	12 306 900	.052
Saloons		104	46 733 600	.198
Shipping, wharves, etc		64	216 343 600	.918
Slaughtering		2	24 968 200	.106
Stables		339	169 242 500	.718
Stone crushers		7	1 488 500	.006
Stone works		6	19 605 100	.083
Storage warehouses		27	26 157 600	.111
Sugar refineries		1	246 196 700	1.045
Tanneries		5	3 366 000	.014
			6 535 621 300	27.736
Somerville.				
(Population, 74 400.)				
Bakeries		7	913 300	.033
Breweries		1	2 137 800	.078
Coal dealers		1	668 700	.025
Contractors		2	801 900	.029
Dye works		2	4 730 400	.174
Electric companies		1	374 700	.014
Elevators and motors		8	1 765 300	.065
Factories and machine shops		43	37 133 000	1.364
Farms and greenhouses		2	750 200	.028
Hotels		10	4 731 800	.174
Iron works		1	112 700	.004
Laundries		5	12 431 000	.456
Offices and stores		535	19 669 100	.722
Oils and chemicals		1	712 100	.026
Railways		2		
Boston & Maine	148 789 900			
Boston Elevated	2 964 300			
			151 754 200	5.573

		Number.	Gallons.	Per Capita per Day.
Slaughtering		3		
North Packing & Provision Co.,	92 847 700			
John P. Squire	59 820 600			
N. E. Dressed Meat & Wool Co.,	43 627 800			
			196 296 100	7.209
Stables		57	17 805 200	.654
			452 787 500	16.628

Malden.

(Population, 42 140.)

Bakeries		3	229 600	.015
Coal dealers		11	1 302 300	.084
Contractors		2	449 600	.029
Dye houses		1	768 200	.050
Electric companies		1	19 149 500	1.242
Elevators and motors		2	1 828 300	.119
Factories and machine shops		34	16 491 200	1.069
Farms and greenhouses		15	1 371 900	.089
Gas works		2	14 731 100	.955
Hotels		3	806 300	.052
Laundries		6	6 093 200	.395
Offices and stores		278	25 882 600	1.678
Oils and chemicals		2	3 600 900	.234
Railways		3	2 460 200	.160
Rubber works		2	3 197 700	.207
Shipping		1	44 100	.003
Stables		22	2 330 800	.151
Stone works		3	66 600	.004
Tanneries		1	334 400	.022
			101 138 500	6.558

Chelsea.

(Population, 32 190.)

Bakeries		14	2 639 800	.225
Coal dealers		3	2 820 000	.240
Dye works		1	770 400	.066
Electric companies		1	748 000	.064
Elevators and motors		2	104 700	.009
Factories and machine shops		51		
Forbes Lithograph	18 423 200			
Others	38 118 100			
			56 541 300	4.812

		Number.	Gallons.	Per Capita per Day.
Gas works		1	134 600	.011
Hotels		7	1 226 700	.104
Iron works		2	9 447 200	.804
Laundries		6	11 451 900	.975
Offices and stores		356	10 839 400	.922
Oils and chemicals		2	336 600	.029
Railways		3		
Boston & Northern	38 851 100			
Others	2 027 100			
			40 878 200	3.479
Restaurants and saloons		32	3 488 000	.297
Rubber works		2		
Revere Rubber Works	91 218 600			
Boston Rubber Works	59 800			
			91 278 400	7.769
Shipping (1 yard, 3 wharves)			7 495 000	.638
Stables		31	4 645 100	.395
			244 845 300	20.839

Everett.

(Population, 31 930.)

Breweries		4	999 300	.086
Contractors		1	1 032 700	.088
Dye works		1	213 200	.018
Elevators and motors		3	126 400	.011
Factories and machine shops		21		
Massachusetts Steel Casting Co.,	11 781 000			
Others	14 856 000			
			26 637 000	2.279
Farms and greenhouses		7	807 000	.069
Gas works		2		
Boston Consolidated	9 666 400			
New England Gas & Coke Co.	123 982 500			
			133 648 900	11.436
Hotels		1	733 000	.063
Laundries		3	5 460 600	.467
Offices and stores		40	2 618 000	.224
Oils and chemicals		1	36 539 800	3.127
Railways		1	710 600	.061
Stables		4	1 653 100	.141
			211 169 600	18.070

Quincy.

(Population, 31 010.)

	Number.	Gallons.	Per Capita per Day.
Electric companies	1	8 443 700	.744
Elevators and motors	2	115 200	.010
* Factories and machine shops	12	129 363 100	11.398
Farms and greenhouses	10	3 124 400	.275
Gas works	1	1 354 000	.119
† Granite and stone works	53	24 751 300	2.181
Hotels	3	1 665 100	.147
Laundries	5	3 772 900	.333
Offices and stores	45	10 843 600	.955
‡ Railways	3	30 943 300	2.726
Shipping	5	596 600	.053
Stables	11	1 307 200	.115
Miscellaneous	6	743 100	.066
		217 023 500	19.122

Medford.

(Population, 21 920.)

Brick yards	2	2 375 500	.296
Dye works	2	5 034 500	.627
Factories and machine shops	8	3 192 800	.398
Farms and greenhouses	7	845 000	.105
Hotels	1	640 400	.080
Iron works	1	955 800	.119
Laundries	2	1 155 100	.144
Offices and stores	131	3 847 900	.480
Oils and chemicals	2	19 720 400	2.458
Railways	2	12 723 300	1.586
Stables	13	2 107 100	.263
		52 597 800	6.556

* Fore River Ship Building Company used 101 690 600 gal.
† The three largest works used over 3 000 000 gal.
‡ Old Colony St. Ry. Power House used 30 209 000 gal.

Melrose.

(Population, 15 210.)

	Number.	Gallons.	Per Capita per Day.
Bakeries	2	235 400	.042
Elevators and motors	3	131 200	.024
Factories and machine shops	4	1 495 700	.269
Farms and greenhouses	5	494 500	.089
Hotels	3	933 400	.168
Laundries	2	1 713 200	.308
Offices and stores	99	2 750 400	.494
Oils and chemicals	1	41 000	.007
Railways	2	1 229 100	.221
Rubber works	1	64 200	.011
Stables	15	2 473 000	.444
		11 561 100	2.077

Revere.

(Population, 16 240.)

Bakeries	1	717 700	.121
Contractors	2	231 900	.039
Elevators and motors	2	58 800	.010
Farms and greenhouses	2	579 700	.097
Gas and electric companies	1	4 288 900	.721
Hotels	1	209 100	.035
Laundries	1	2 119 600	.357
Manufacturing establishments	2	342 200	.058
Offices and stores	3	378 500	.064
Railways	2	2 026 000	.341
Stables		287 900	.048
		11 240 300	1.891

Watertown.

(Population, 12 300.)

	Number.	Gallons.	Per Capita Per Day.
Coal yard	1	89 800	.020
Dye houses	1	533 300	.119
Factories and machine shops	15	23 518 600	5.224
Farms and greenhouses	31	8 813 600	1.958
Gas works	1	552 000	.123
Hotels	1	108 500	.024
Laundries	4	446 600	.099
Offices and stores	60	3 759 200	.835
Railways	2	960 400	.213
Restaurants	3	110 000	.024
Slaughtering	1	221 400	.049
Stables	15	1 062 200	.236
		40 175 600	8.924

Arlington.

(Population, 10 650.)

Bakeries	1	184 400	.047
Factories and machine shops	4	1 697 400	.435
Farms and greenhouses	50	29 911 800	7.674
Gas works	1	2 276 200	.584
Hotels	2	299 100	.077
Offices and stores	45	2 361 800	.606
Oils and chemicals	1	1 773 400	.455
Railways	3	1 608 400	.413
Stables	9	1 041 900	.267
		41 154 400	10.558

Winthrop.

(Population, 9 030.)

Elevators and motors	2	941 800	.285
Greenhouses	1	878 500	.266
Hotels	1	1 031 300	.312
Laundries	1	154 400	.047
Offices, stores, etc.	10	367 700	.111
Railways	1	286 300	.086
		3 660 000	1.107

Milton.

(Population, 7 610.)

	Number.	Gallons.	Per Capita Per Day
Bakeries	2	314 500	.113
Coal wharf	1	81 500	.029
Elevators and motors	2	114 400	.041
Factories and machine shops	5	989 900	.355
Farms and greenhouses	30	3 070 400	1.102
Hotels	1	157 500	.057
Laundries	2	520 200	.187
Offices and stores	16	1 358 300	.488
Railways	3	175 000	.063
Stables	34	1 770 100	.635
		8 551 800	3.070

Stoneham.

(Population, 6 820.)

Factories and machine shops	9	8 856 500	3.548
Farms and greenhouses	5	576 300	.231
Oils and chemicals	1	263 100	.105
Railways	1	4 904 200	1.965
Stables	2	595 600	.239
		15 195 700	6.088

Swampscott.

(Population, 5 830.)

Elevators and motors	2	3 229 100	1.514
Farms and greenhouses	3	2 469 000	1.157
Hotels	1	1 485 400	.696
Offices and stores	9	152 100	.071
Stables	9	945 300	.443
		8 280 900	3.881

Lexington.

(Population, 4 780.)

	Number.	Gallons.	Per Capita Per Day.
Farms and greenhouses	9	1 751 200	1.001
Gas works	1	60 500	.034
Railways	2	1 818 900	1.040
		3 630 600	2.075

Belmont.

(Population, 5 120.)

Blacksmith and carriage shop	1	38 100	.020
Coal company	1	118 600	.063
Farms and greenhouses	88	22 050 300	11.767
Hotels	1	417 400	.223
Offices and stores	23	1 201 300	.641
Railways	1	99 500	.053
Stables	7	457 900	.245
		24 383 100	13.012

Nahant.

(Population, 1 090.)

Hotels	1	303 600	.761
Shipping		2 375 400	5.954
Stables	4	945 700	2.371
		3 624 700	9.086

The consumption of water for trade purposes in Fall River during the year 1910, amounted to 281 886 267 gal., or 6.5 gal. per capita.

Mr. James H. Fuertes, in his report to the Merchants' Association of New York, 1906, gives the following subdivision of water consumption, as between domestic, manufacturing, and public uses:

TABLE 33.

SUBDIVISION OF CONSUMPTION INTO VARIOUS USES.

(Report of Mr. Jas. H. Fuertes to Merchants' Association, New York, 1906.)

(In Gallons per Day per Capita.)

Place.	Year.	Consumers' Use.			Public Uses.	Not Accounted For.	Total Cons.	Per Cent. Unaccounted For.	Per Cent. Metered
		Mfg.	Domestic.	Total.					
Brockton .	1904	5.1	15.5	20.6	3.0	13.3	36.9	26	91
Boston . . .	1892	30.0	30.0	60.0	3.0	32.0	95.0	34	. .
Cleveland.	1904	40.0	26.0	66.0	10.0	20.0	96.0	21	49
Fall River	1902	. . . .	. . . .	23.4	8.3	8.7	40.5	21	95
Hartford. .	1904	3.0	30.0	33.0	5.0	24.0	62.0	39	99
Harrisburg	1904	81.0	30.0	111.0	5.0	30.0	146.0	21	75 ±
Lawrence .	1904	8.0	17.0	25.0	5.0	12.0	42.0	29	87
Milwaukee	1904	45.0	25.0	70.0	5.0	14.0	89.0	16	79
Madison. .	1904	. . . .	. . . .	21.0	13.0	37.0	71.0	52	96
Syracuse. .	1904	39.3	31.0	70.3	18.0	20.0	108.3	19	72
Taunton. .	1904	14.7	21.5	36.2	3.0	24.8	64.0	39	45
Wellesley .	1904	0.4	28.6	29.0	2.5	23.5	55.0	43	100
Yonkers . .	1904	24.0	20.0	57.5	2.0	40.5	94.0	43	100

Mr. Rudolph Hering reports the following use of water for trade purposes in Germany:

TABLE 34.

WATER CONSUMPTION IN GERMANY FOR DIFFERENT PURPOSES, 1909.

(From report of Mr. Rudolph Hering to Mr. J. Waldo Smith, Chief Engineer, New York Additional Water Supply, by courtesy of the latter.)

For Trade Purposes (daily).

	Liters. Per Day.	U. S. Gal. Per Day.
Feed water for condensing engines, per h.p. per hour . .	6–12	1.58–3.17
Feed water for small non-condensing engines, per h.p. per hour	25–35	6.60–8.24

Water for condensation is 25 to 35 times the feed water.

For breweries, five times the quantity of produced beer.

For cleaning one carriage, 200 liters (52.84 U. S. gal.).

For horses and cattle, per head, 30 to 50 liters (7.92 to 13.2 U. S. gal.).

PUBLIC USES.

AT FIRES.

The total amount of water used at fires during the course of the year is comparatively small. The rate at which the water is used for short periods of time at different fires, is, on the other hand, likely to be large. In the following table are shown some of the standards of service suggested in the past by different engineers and underwriters. These are followed by diagrams reprinted from a paper presented by Metcalf, Kuichling, and Hawley, before the American Water Works Association, June, 1911.

TABLE 35.

STANDARDS FOR AMOUNT OF WATER REQUIRED FOR FIRE PROTECTION.

J. HERBERT SHEDD, JOURNAL N. E. W. W. A., Vol. 3, p. 113, March, 1889, suggests for population of —

5 000	5 streams of 200 gal.
10 000	7 streams of 200 gal.
20 000	10 streams of 200 gal.
40 000	14 streams of 200 gal.
60 000	17 streams of 200 gal.
100 000	22 streams of 200 gal.
180 000	30 streams of 200 gal.

JOHN R. FREEMAN, JOURNAL N. E. W. W. A., Vol. 7, p. 49, September, 1892:

Total Population.	No. of 250-gal. Streams required simultaneously in Addition to Maximum Domestic Draft.
1 000	2 to 3
5 000	4 to 8
10 000	6 to 12
20 000	8 to 15
40 000	12 to 18
60 000	15 to 22
100 000	20 to 30
200 000	30 to 50

Ten of the streams to be concentrated for any large group of buildings, irrespective of small population, if possible. In a city, two thirds of the streams mentioned should be capable of being concentrated on a large square.

KUICHLING-HAZEN, 1897:

$$C = Q + 20P + 1\,000\,000\sqrt{\frac{P}{1\,000}}.$$

C = Required capacity of plant in g.p.d.
Q = Average daily quantity consumption, in gallons.
P = Population.

TABLE 35 (*Continued*).

STANDARDS FOR AMOUNT OF WATER REQUIRED FOR FIRE PROTECTION.

UNDERWRITERS ASSOCIATION OF THE MIDDLE DEPARTMENT, July, 1904:

Fire streams, 250 g.p.m. Domestic, 50 to 80 g.p.d. per capita.

Population.	Streams	Fire Flow	Domestic.	Total (Mgd.).
1 000	2	0.72	0.05	0.77
2 000	3	1.08	0.10	1.18
3 000	5	1.80	0.15	1.95
4 000	7	2.52	0.20	2.72
5 000	8	2.88	0.25	3.13
6 000	8	2.88	0.30	3.18
8 000	9	3.24	0.45	3.69
10 000	9	3.24	0.60	3.84
15 000	10	3.60	1.00	4.60
20 000	11	3.96	1.40	5.36
25 000	12	4.32	1.90	6.20
30 000	12	4.32	2.40	6.72

J. T. FANNING, AM. W. W. A., 1906:

4 000 to 10 000	7 to 19 fire streams 54 lb. at nozzle.
10 000 to 50 000	10 to 14 fire streams 54 lb. at nozzle.
50 000 to 100 000	14 to 18 fire streams 54 lb. at nozzle.
100 000 to 150 000	18 to 25 fire streams 54 lb. at nozzle.

$1\frac{1}{8}$ in. nozzle (smooth), 250 ft. rubber-lined hose, 43 lb. base of nozzle, 68 ft. effective height, 247 gal. per minute.

THE NATIONAL BOARD OF FIRE UNDERWRITERS (courtesy of Geo. W. Booth, March, 1911), have prepared a plot of the engine capacity in gallons per minute in all of the cities examined, giving not only the actual rated capacity, but the total capacity including recommendations of the board. These cities indicated that Mr. Kuichling's summary is adequate for populations up to 1 000; fairly represents the actual conditions in cities of 200 000 or 250 000 population; but gives altogether too small results for the large cities. The underwriters' investigations indicate that a straight line, rather than a curve, more nearly meets actual conditions and their requirements. They indicate requirements corresponding to the following summary.

Required engine capacity allowance, 2 000 g.p.m. + 58 × population in thousands.

A more conservative line, which seems to me preferable, which they also show, is as follows:

Required engine capacity = 1 000 g.p.m. + 58 × population in thousands.

TABLE 35 (*Continued*).

STANDARDS FOR AMOUNT OF WATER REQUIRED FOR FIRE PROTECTION.

MR. GEORGE W. BOOTH, CHIEF ENGINEER OF THE NATIONAL BOARD OF FIRE UNDERWRITERS, presents the following data in regard to their present standards, under date March 22, 1911:

Required engine capacity = 2 000 g.p.m. + 58 × population in thousands.

Required engine capacity = 1 000 g.p.m. + 58 × population in thousands.

Number of engine companies = 4 + 0.8 × population in thousands.

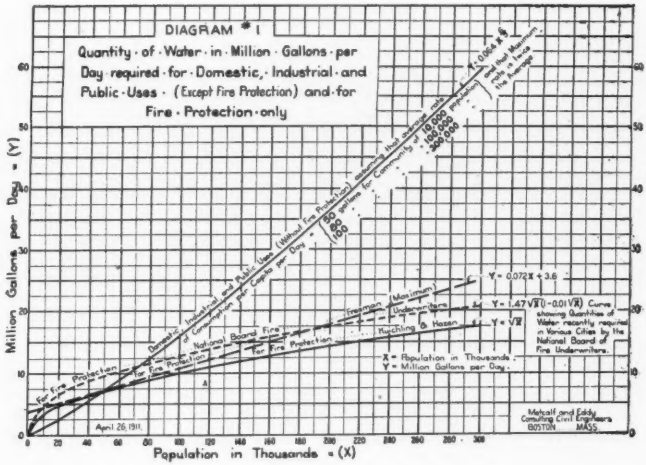
DIAGRAM # 1
Quantity of Water in Million Gallons per Day required for Domestic, Industrial and Public Uses (Except Fire Protection) and for Fire Protection only
Million Gallons per Day = (Y)
Population in Thousands = (X)
Y = 0.072X + 3.6
Y = 1.47√X (1) - 0.01√X) Curve showing Quantities of Water recently required in Various Cities by the National Board of Fire Underwriters.
Y = √X
X = Population in Thousands.
Y = Million Gallons per Day.
April 26, 1911.
Metcalf and Eddy Consulting Civil Engineers BOSTON MASS.

FIG. 16.

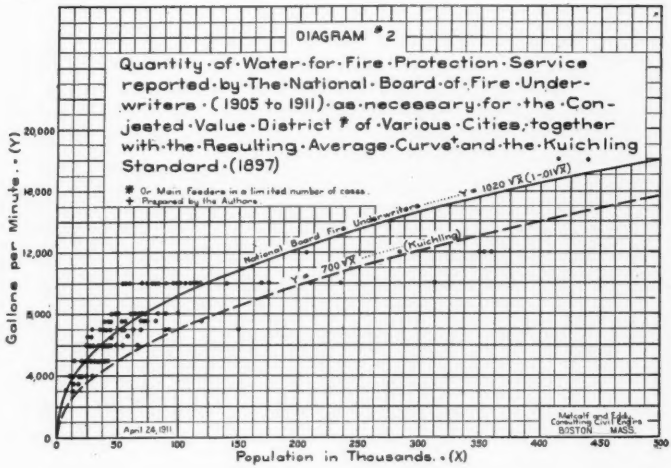
DIAGRAM # 2
Quantity of Water for Fire Protection Service reported by The National Board of Fire Underwriters (1905 to 1911) as neceeeary for the Conjested Value District # of Various Cities, together with the Resulting Average Curve+ and the Kuichling Standard (1897)
Or Main Feeders in a limited number of cases.
+ Prepared by the Authors
Gallons per Minute. = (Y)
Population in Thousands. = (X)
National Board Fire Underwriters ..... Y = 1020 √X (1 - .01√X)
Y = 700 √X ..... & (Kuichling)
April 24, 1911.
Metcalf and Eddy Consulting Civil Engineers BOSTON MASS.

FIG. 17.

THE USE OF WATER IN SCHOOLS.

Tables 36 and 37 cover the use of water in schools in the Metropolitan District, surrounding Boston, and in Syracuse, N. Y.

TABLE 36.

WATER USED FOR SCHOOLS AND STREETS IN METROPOLITAN DISTRICT. (M. & E., in reports of Boston Finance Commission, Vol. 3, October, 1908.)

CITY OR TOWN.	SCHOOLS.			STREET SPRINKLING, 1901.
	Year.	Daily Consumption.		Metropolitan District. Gal. per Capita per Day.
		Per Pupil.	Per Inhabitant.	
Arlington	1901	....	....	2.12
Belmont	1902	6.96	0.48	1.47
Boston	1899	6.22	0.41	2.35
Chelsea	....	....	....	1.12
Malden	1901	2.21	0.17	1.87
	1902	2.26	0.18	....
Medford	1901	4.02	0.33	3.41
	1902	4.11	0.34	....
Melrose	....	....	....	2.06
Milton	1901	6.56	0.53	5.87
Nahant	....	....	....	8.63
Quincy	....	....	....	1.43
Revere	....	....	....	0.96
Somerville	1899	6.29	0.46	1.97
Stoneham	....	....	....	0.60
Swampscott	....	....	....	3.67
Watertown	....	....	....	3.67
Winthrop	....	....	....	2.48
Average for Metropolitan Water District				2.13

John Venner, "Municipal Use and Waste of Water," in JOURNAL N. E. W. W. A., Vol. 17, p. 268, September, 1903, gives data on use of water in the 34 public schools of Syracuse, N. Y., three months, March–May, 1903.

The following table shows the daily consumption of water per pupil, in gallons, based upon the average daily attendance in each school.

TABLE 37.

DAILY CONSUMPTION OF WATER PER PUPIL IN THE PUBLIC SCHOOLS OF SYRACUSE, N. Y., FOR THREE MONTHS OF 1903.

School.	Average Daily Attendance.	Per Capita Consumption, in Gallons.		
		March.	April.	May.
1. Jefferson	314	17.8	21.1	24.1
2. Grant	304	22.2	25.2	24.4
3. Townsend	481	5.4	5.7	5.5
4. Garfield	434	5.1	6.6	5.2
5. Franklin	826	4.1	3.5	2.4
6. Prescott	574	9.4	9.2	6.0
7. Clinton	522	16.2	15.3	14.7
8. Lincoln	414	9.1	8.0	7.8
9. Vine	218	2.3	4.2	4.1
10. Frazer	428	12.8	14.2	11.0
11. Genesee	412	6.0	3.2	2.9
12. Commercial	86	397.0	381.0	497.0
13. May	426	110.0	114.0	117.0
14. Tompkins	388	5.6	6.1	8.7
15. Porter	778	4.5	4.5	3.2
16. Gere	352	33.0	33.5	22.5
17. Madison	529	40.7	39.4	32.8
18. Sumner	358	20.9	20.0	15.7
19. Washington Irving	439	35.3	30.9	22.6
20. Willard	81	188.8	190.0	104.4
21. Montgomery	471	5.1	4.1	4.0
22. Putnam	650	21.6	16.7	12.6
23. Andrew Jackson	353	3.5	2.9	3.9
24. Croton	605	44.5	31.2	28.0
25. New High School	1 267	8.9	9.4	9.0
26. Seymour	665	26.3	23.6	23.6
27. Truant School	16	22.3	38.2	52.2
28. Delaware	523	7.5	9.2	6.6
29. Grace	259	16.8	24.3	30.9
30. Merrick	294	35.6	17.9	22.3
31. Bellevue	257	32.1	32.8	37.9
32. Danforth	348	25.9	21.4	22.0
33. Elmwood	224	8.4	14.5	14.5
34. Brighton	868	5.3	4.1	3.0
Average, 20 gal.				

For the three months, the use in the schools amounted to 3.6 per cent. of the entire consumption of the city.

The general uses of water for public purposes are indicated by the statistics shown in Tables 38 to 44, covering the public uses of water in the cities and towns of the Metropolitan District, Brookline, Fall River, Woonsocket, Canandaigua, and Cleveland.

TABLE 38.

WATER SUPPLIED BY METER (ONLY) FOR PUBLIC PURPOSES IN THE METROPOLITAN WATER DISTRICT. 1908.

(By courtesy of Mr. Dexter Brackett.)

Boston.

(Population, 643 810.)

		Number.	Gallons.	Per Capita per Day.
Boston Protective Department Wagon No. 2			471 000	.002
Cemeteries		2	3 186 500	.013
Colleges		10	51 784 000	.220
Metropolitan Water and Sewerage Board			39 733 800	.169
National, state, or county buildings		15		
Navy Yard	211 953 300			
U. S. Gov., Gallups Is	25 783 600			
Post Office	23 621 800			
State Prison	19 799 600			
State House	15 805 200			
Others	34 677 300			
			331 640 800	1.407
Schools:				
Private		14	8 355 200	.072
Parochial		21	8 512 200	
State Board of Health, Pathological Laboratory,			351 600	.010
Street watering, Park Department		...	39 045 600	.166
			483 080 900	2.050

(Public schools, public buildings owned by city, street watering, and other public uses are not metered.)

Somerville.

(Population, 74 400.)

	Number.	Gallons.	Per Capita per Day.
Metropolitan Park Commission, Wellington Bridge		162 300	
Metropolitan Sewerage Works, Alewife Brook Pumping Station		1 085 300	
National, state, or county buildings (armory)	1	543 000	
St. Joseph's Parochial School		225 200	
Street watering (estimated by street commissioner)		63 912 000	
Tufts College, Metcalf Hall		477 200	
		66 405 000	2.439

(Schools and municipal buildings not metered.)

Malden.

(Population, 42 140.)

Cemeteries	2	365 300	
Fire stations	6	653 800	
High school field		20 000	
Metropolitan Park boulevard		88 100	
Municipal departments		1 142 900	
National, state, or county buildings		1 161 600	
Schools:			
Public	20	7 004 000	
Private	1	53 900	
Parochial	2	214 700	
Street watering (figured by cartloads)		42 468 300	
		53 172 600	3.448

Chelsea.

(Population, 32 190.)

Drawtender's house, Chelsea Bridge		546 000	
National, state, or county buildings:			
Court house	1 735 400		
Naval hospital	10 756 200		
Soldiers' home	14 960 000		
		27 451 600	
Schools:			
Public	4	3 545 500	
Parochial	1	306 700	
Street watering (record kept by cartloads)		7 870 800	
		39 720 600	3.381

Everett.

(Population, 31 930.)

	Number.	Gallons.	Per Capita per Day.
Cemeteries	2	1 026 300	
Municipal departments	1	471 200	
Public fountains	1	21 700	
Schools, public	1	590 900	
State armory	1	102 500	
		2 212 600	.189

Quincy.

(Population, 31 010.)

Metropolitan Sewerage Works		3 097 800	
Metropolitan Park Commission		970 400	
Street watering (estimated by commissioner)		23 560 000	
United States Government (Fort Andrew)		22 553 000	
		50 181 200	4.421

Medford.

(Population, 21 920.)

Fire stations	5	393 900	
Metropolitan Park Commission		340 000	
Metropolitan Water Works, Glenwood Pipe Yard		130 000	
Municipal departments		1 334 200	
National, state, or county buildings	1	519 400	
Public schools	18	3 995 300	
Street watering (estimated from data furnished by water registrar)		24 562 700	
		31 275 500	3.898

Melrose.

None.

Revere.

(Population, 16 240.)

Metropolitan Park (public fountain)		76 500	
Municipal departments		402 700	
Schools, public	9	2 349 000	
		2 828 200	.476

Watertown.

(Population, 12 300.)

	Number.	Gallons.	Per Capita per Day.
Cemeteries	2	493 700	
Fire station		216 900	
Municipal departments		1 178 900	
Schools:			
Public	10	2 930 700	
Private	1	70 300	
Parochial		10 500	
Street watering		19 618 900	
Watertown arsenal		22 915 700	
		47 435 600	10.537

Arlington.

(Population, 10 650.)

Cemeteries	1	15 900	
Public library		316 300	
Street watering (estimated by town engineer)		7 000 000	
		7 332 200	1.881

Winthrop.

(Population, 9 030.)

Schools, public	3	400 600	
Street watering (figured by cartloads)		7 635 000	
United States government buildings		1 539 300	
		9 574 900	2.897

Milton.

(Population, 7 610.)

Cemeteries	1	121 300	
Fire stations	3	211 300	
Metropolitan Park Commission, street watering		1 293 700	
Metropolitan Park Commission, fountain, police station, etc.		257 100	
Municipal departments	9	635 300	
Public fountains	4	946 100	
Schools:			
Public	8	1 353 500	
Private	2	2 144 300	
Street watering		9 146 000	
		16 108 600	5.784

Stoneham.

	Number.	Gallons.	Per Capita per Day.
None.			

Swampscott.

(Population, 5 830.)

Municipal departments	2	144 400	
Public schools	4	2 650 600	
		2 795 000	1.310

Lexington.

None.

Belmont.

(Population, 5 120.)

Cemeteries	1	369 500	
Fire stations	1	38 100	
Metropolitan Park		60 600	
Schools:			
Public	5	1 131 000	
Private	1	114 400	
Street watering (estimated by superintendent of streets)		2 640 000	
Town departments		699 400	
		5 053 000	2.696

Nahant.

(Population, 1 090.)

State bath house	1	1 133 400	2.841

TABLE 39.

WATER SUPPLIED BY METER (ONLY) FOR MISCELLANEOUS PURPOSES IN THE METROPOLITAN WATER DISTRICT, 1908.

(By courtesy of Mr. Dexter Brackett.)

Boston (1908).

(Population, 643 810.)

		Number.	Gallons.	Per Capita per Day.
Clubs		36	67 110 600	.285
Halls		10	13 314 400	.057
Homes		11	8 587 000	.036
Hospitals		28		
Massachusetts General	30 413 700			
Massachusetts Homœopathic	15 408 800			
Others	48 679 800			
			94 502 300	.401
Laboratories		2	837 800	.004
Museums		2	1 967 200	.008
Playgrounds		3	3 358 500	.014
Public baths		8	6 636 400	.028
Religious societies		12	9 935 300	.042
Skating rinks		2	2 004 600	.009
Theaters		19	28 528 700	.121
			236 782 800	1.005

Somerville.

(Population, 74 400.)

Clubs		4	411 400	
Religious societies		11	7 413 400	
Somerville hospital			1 647 800	
			9 472 600	.348

Malden.

(Population, 42 140.)

Baths		2	310 000	
Clubs		6	402 400	
Halls		2	259 600	
Hospitals		3	3 237 300	
Religious societies		37	4 191 000	
Theaters		1	1 341 200	
			9 741 500	.632

Chelsea.
(Population, 32 190.)

	Number.	Gallons.	Per Capita per Day.
Baths	4	1 084 600	
Clubs	1	15 000	
Halls	2	209 400	
Religious societies	5	320 500	
		1 629 500	.139

Everett.
(Population, 31 930.)

Clubs	1	92 000	
Building purposes		41 900	
		133 900	.011

Quincy.
(Population, 31 010.)

Clubs	5	1 848 600	.163

Medford.
(Population, 21 920.)

Building purposes		5 632 500	
Clubs	2	80 300	
Combination Park		122 200	
Halls	1	32 500	
Pasture taps	6	202 700	
Religious societies	9	703 400	
Sanitariums	1	257 500	
Steam engines	2	173 800	
Theaters	1	94 900	
Tufts College		1 496 900	
		8 796 700	1.096

Melrose.
(Population, 15 210.)

Clubs	2	70 000	
Hospitals	3	561 700	
New England Sanitarium		3 315 700	
Religious societies	4	1 598 000	
		5 545 400	.996

Revere.
(Population, 16 240.)

Amusement places	4	6 167 400	
Theaters	1	283 900	
		6 451 300	1.085

Watertown.

(Population, 12 300.)

	Number.	Gallons.	Per Capita per Day.
Clubs	2	944 700	
Religious societies	12	1 349 400	
		2 294 100	.510

Arlington.

(Population, 10 660.)

Clubs	2	404 400	
Halls	1	30 800	
Institutions	2	734 800	
Religious societies	1	14 400	
		1 184 400	.304

Winthrop.

(Population, 9 030.)

Churches	1	26 600	
Hospitals	1	205 300	
		231 900	.070

Milton.

(Population, 7 610.)

Clubs	2	76 800	
Fire supply (private)	1	74 800	
Hospital	1	405 000	
Religious societies	7	850 500	
Watering trough (private)		2 600	
		1 409 700	.506

Stoneham.

None.

Swampscott.

(Population, 5 830.)

Hospitals	1	17 400	
Religious societies	2	110 100	
		127 500	.060

Lexington.

(Population, 4 780.)

Lexington Park		808 300	.462

Belmont.

(Population, 5 120.)

	Number.	Gallons.	Per Capita per Day.
Clubs	3	191 500	
Religious societies	5	178 000	
McLean Hospital		10 878 900	
		11 248 400	6.003

Nahant.

(Population, 1 090.)

Clubs	1	424 700	
Lawns	4	772 900	
		1 197 600	3.002

TABLE 40.

Brookline, Mass. PUBLIC USES OF WATER. RECORD IN 1905, ALL SERVICES METERED.

Bathhouses	2.02 gal. per day per capita.
Miscellaneous public buildings	0.20 gal. per day per capita.
Fire Department buildings	0.12 gal. per day per capita.
Schools	1.13 gal. per day per capita.
Street Department	0.03 gal. per day per capita.
Water Department	1.11 gal. per day per capita.
Drinking fountains	0.83 gal. per day per capita.
Street watering	6.60 gal. per day per capita.
Flushing sewers, extinguishing fires, puddling trenches, etc.	1.01 gal. per day per capita.
Total public uses	13.05 gal. per day per capita.

Of the metered water, the town used 20.7 per cent. and private consumers 79.3 per cent. But 14 per cent. of the water pumped was unaccounted for by the meters.

TABLE 41.

Fall River, Mass. QUANTITIES OF WATER USED FOR PUBLIC PURPOSES. 1910.

(Population, 118 645.)

	Quantity in Million Gallons.	Consumption, in Gallons per Capita per Day.
Schools	77 300 000	1.79
Public buildings	54 891 170	1.27
Street watering	131 000 000	3.03
Sewer flushing	18 450 000	0.43
Fires	12 700 000	0.29
Water troughs and urinals	104 800 000	2.42
Miscellaneous	154 300 000	3.56
Total		12.79

TABLE 42.

Cleveland, Ohio. AMOUNT OF WATER FURNISHED FREE FOR PUBLIC PURPOSES, OCTOBER 1, 1909, TO OCTOBER 1, 1910.
(From report of Department of Public Works.)

	Total Consumption (Million Gallons).	Gallons per Capita per Day. Figured on Total Population (630 000).
Public schools	266.6	1.16
Private and parochial schools	46.4	0.20
Hospitals	175.3	0.76
Orphan asylums, homes, etc	117.9	0.51
Public buildings (police and fire stations, etc.)	401.1	1.74
Cemeteries	31.9	0.14
Parks and fountains	119.5	0.52
Flushing sewers	62.0	0.27
Cleaning streets	200.0	0.87
Fires	35.1	0.15
Sewer and paving construction	55.4	0.24
Watering troughs	148.7	0.65
Total		6.31

TABLE 43.

Woonsocket, R. I. MUNICIPAL USE OF WATER, 1911.

	Total Consumption (Million Gallons).	Gallons per Capita per Day Figured on Total Population (44 200).
Flushing dead ends	1.0	0.06
Street watering	18.4	1.14
Sewer flushing	0.7	0.04
Drinking fountains	20.0	1.24
Schools	17.0	1.05
Hospitals	1.4	0.09
Charitable institutions	17.3	1.07
Fire Department	0.6	0.04
Public buildings	12.4	0.77
Fires	1.2	0.07
Total		5.57

TABLE 44.

Canandaigua, N. Y. PUBLIC USES OF WATER, 1911.

	Consumption in Million Gallons, March 1, 1910, to March 1, 1911.	Consumption, Gallons per Capita per Day (Population 7 500).
Asylums	4.44	1.62
Hospitals	3.93	1.43
Churches	1.01	0.37
Public buildings	5.80	2.12
Schools	1.54	0.56
Parks and fountains	2.62	0.96
Pumping station	1.24	0.45
Street sprinkling	8.00 (estimated)	2.92
Sewer flushing	5.00 (estimated)	1.82
Total		12.25

Dexter Brackett, JOURNAL N. E. W. W. A., Vol. 18, p. 127, gives summary of uses for public purposes in cities of Massachusetts Metropolitan Water District for 1902 and finds the total to be 7.11 gal. per capita of population supplied.

Interesting data concerning water consumption for public purposes in Germany were submitted by Mr. Rudolph Hering (1909) to Mr. J. Waldo Smith, chief engineer of the New York Additional Water Supply, by whose courtesy they are reproduced herewith.

TABLE 45.

WATER CONSUMPTION IN GERMANY, FOR DIFFERENT PURPOSES.

For Public Purposes (daily):

	Liters per Sq. Meter.	U. S. Gal. per Sq. Yd.
Paved streets, sprinkling	1.0	0.22
Macadamized streets	1.5	0.33
Gardens and lawns	1.5	0.33
Markets	5.0	1.10
	Liters.	**U. S. Gallons.**
Sewer flushing, per head of population	1–8	0.264–2.11
Self-flushing urinals, per hour	50.0	13.21
Abattoirs, per animal	300.0	79.26
Hospitals, per person	120.0	30.50
Soldiers in barracks, per person	40.0	10.56
Hotels, per person	100.0	26.4

LEAKAGE AND WATER-UNACCOUNTED-FOR.

The amount of water lost by leakage from main pipes, valves and fittings, service connections, etc., — or, in other words, from the distribution pipe system, independent of the waste of water from the faucets and fixtures connected therewith, — is unfortunately large. In general, it may be said that if, in a well-metered system, the water-unaccounted-for does not exceed 25 per cent. of the total pumpage, the practice is good. If, on the other hand, as is often the case, the leakage or water-unaccounted-for amounts to 40 per cent. or more of the pumpage, the practice is not good and it is probable that measures taken to reduce the amount of this

leakage will effect a substantial saving in leakage and consequent reduction in expense of operation.

Two of the best discussions in American literature upon the waste and leakage of water are to be found in the paper of Mr. Dexter Brackett, chief engineer of the Metropolitan Water Works, of Boston, upon "Report on the Measurement, Consumption and Waste of Water Supplied to the Metropolitan Water District," published in the JOURNAL of this Association in June, 1904, Volume 18, and in the report upon New York's Additional Water Supply, rendered to the comptroller of the city, by Mr. John R. Freeman, March 23, 1910.

In Mr. Brackett's article will be found diagrams 1 to 7, bearing upon the waste and leakage of water. Mr. Brackett says (p. 134):

"The tests which have been made in the several municipalities of the Metropolitan District tend to show that the leakage from the street mains and services is very large, and that from 10 000 to 15 000 gal. per mile of street main escape each day into the ground or into some underground channel. If this estimate is correct, the total leakage from the mains and services is from 15 000 000 to 22 500 000 gal. per day, — equivalent to from 16.5 to 25 gal. per inhabitant."

Mr. Freeman's discussion, with accompanying diagrams, will be found on pp. 38 to 83, "Report on New York's Water Supply." He says, —

"My best guess is that the total leakage underground in the streets at present amounts to somewhere between 20 and 35 gal. per inhabitant per day.

"It can never be known with any degree of accuracy just what this underground leakage in the street is until there is a meter on every tap and a daily estimate made of all public uses and draft for fires, when by subtracting what is measured out from what is measured into the distribution system, the difference will give the leakage from the street pipes. This kind of measurement in Fall River and Woonsocket, with the allowance for a smaller number of joints and of service pipes in New York, gives us the ideal of 5 to 10 gal. per inhabitant per day, for maximum leakage of street mains and service pipes toward which the water distribution service of Greater New York should work. To attain this ideal will require years of patient work and very heavy expenditure."

In Mr. Brackett's report of 1904, the following similar conditions, in cities having metered water supplies, are shown.

TABLE 46.

WATER-UNACCOUNTED-FOR IN CITIES WITH METERED SUPPLIES.

City.	Per Cent. Metered.	Unaccounted For.	
		Per Cent.	Gallons per Day per Mile of Pipe.
Brockton	90	32.3	6 200
Ware	100	39.8	11 200
Worcester	94.5	46.5	20 800
Wellesley	100	41.5	3 450
Yonkers	100	45.7	23 340
Fall River	96	21.5	10 000
Woonsocket	87	23.0	4 370

Mr. T. C. Phillips, engineer of water surveys of Chicago, in a recent article (*Engineering and Contracting*, January 1, 1913, p. 11) estimates the present " willful wastage and underground leakage " at 30 per cent. of the daily consumption, or 57 gal. daily per capita, and the " plumbing leakage " at 20 per cent., or 38 gal. daily per capita. In answer to the question, what becomes of the water pumped, he gives the following table:

(1) 37.0 gal. per capita is consumption by frontage consumers.
(2) 44.0 gal. per capita is consumption by meter consumers.
(3) 9.5 gal. per capita is consumption by free service consumers.
(4) 4.5 gal. per capita is slippage of or loss by meters.
(5) 38.0 gal. per capita is plumbing leakage.
(6) 57.0 gal. per capita is willful wastage and underground leakage.

190.0 gal. per capita is total consumption for entire city.

The two following diagrams illustrating the conditions at East Chicago and Indiana Harbor, Ind., and at San Antonio, Tex., reported by Metcalf & Eddy, show similar characteristics.

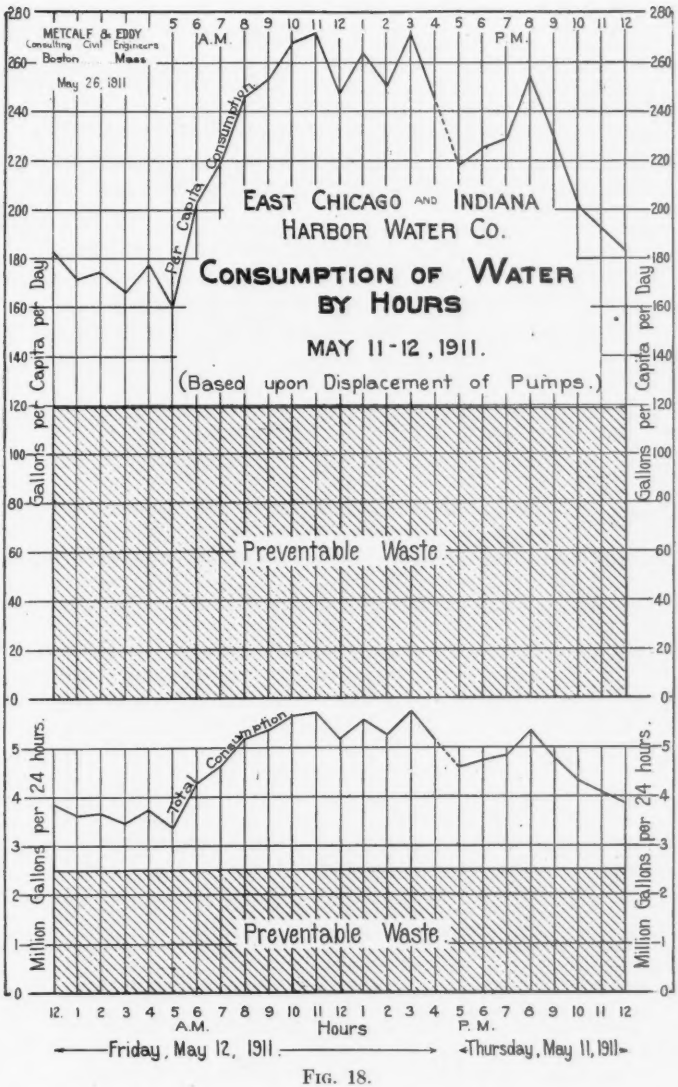
METCALF & EDDY
Consulting Civil Engineers
Boston Mass.
May 26, 1911
A.M.
P.M.
Per Capita Consumption
EAST CHICAGO AND INDIANA HARBOR WATER CO.
CONSUMPTION OF WATER BY HOURS
MAY 11-12, 1911.
(Based upon Displacement of Pumps.)
Gallons per Capita per Day
Preventable Waste
Total Consumption
Million Gallons per 24 hours.
Preventable Waste
Hours
Friday, May 12, 1911
Thursday, May 11, 1911

FIG. 18.

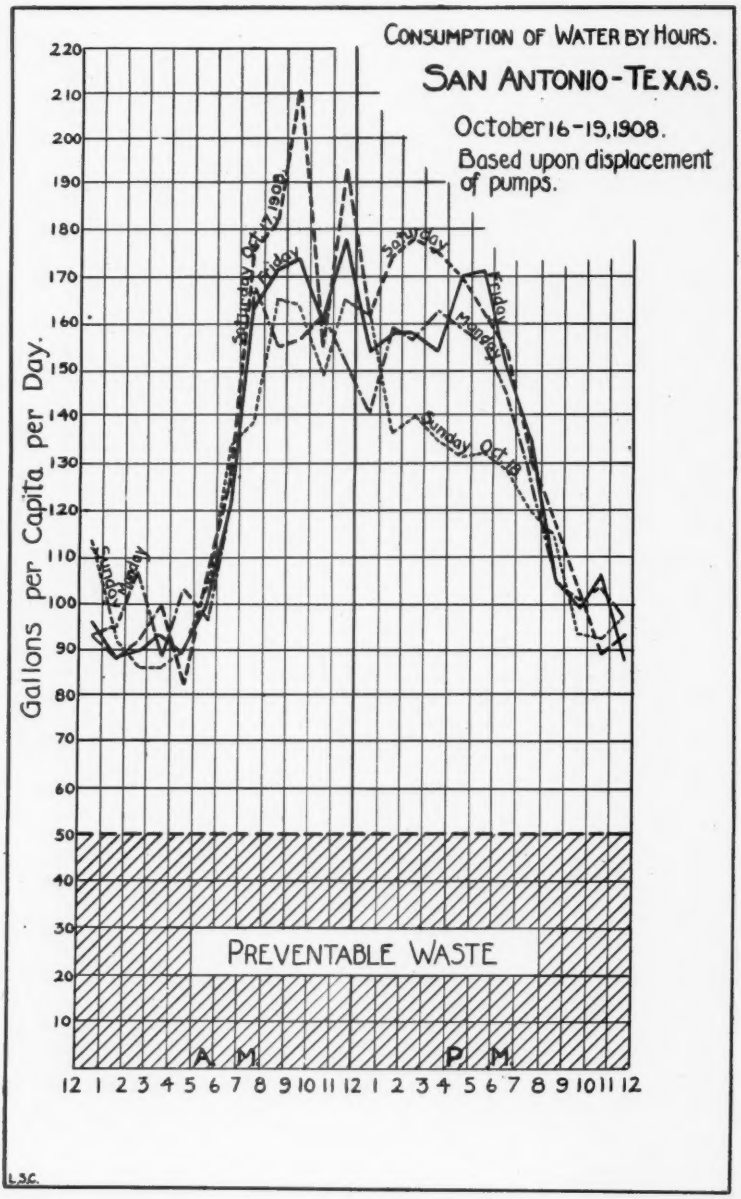
CONSUMPTION OF WATER BY HOURS.
SAN ANTONIO - TEXAS.
October 16 - 19, 1908.
Based upon displacement of pumps.
Gallons per Capita per Day.
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
Saturday Oct. 17, 1908
Friday
Sunday
Monday
Tuesday
Sunday Oct. 18
Thursday
PREVENTABLE WASTE
A M
P M
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
L.S.C.

FIG. 19.

Effect of Industrial Consumption in Increasing per Capita Consumption.

Striking evidence of the important influence of industrial uses of water upon the variation in per capita daily consumption of water in our American cities is furnished in two examples which recently came to the attention of one of the members of this committee.

The first example relates to the water consumption in a city in the heart of the Pennsylvania coal district. The water consumption was found to be 144 gal. per capita per day with a population of approximately 150 000 in the portion of the district covered by these works. Analysis showed, however, a leakage or amount of water-unaccounted-for of approximately 33 per cent., an average consumption of 89 gal. per day by each of the 28 000 consumers, and 17 gal. per day per capita. Most important of all, the domestic consumption was found to be but 18 per cent. of the total water-accounted-for, the remaining 82 per cent. being industrial consumption. Thus while the controlling Venturi meters indicated an average per capita consumption of 144 gal. per day, the domestic consumption was but 17 gal., the industrial consumption 79 gal., and the leakage or water-unaccounted-for, 48 gal. per capita per day.

In the other instance, that of the Champaign and Urbana Water Works (Illinois), the following approximate figures were found.

TABLE 47.

ESTIMATED WATER CONSUMPTION OF CHAMPAIGN AND URBANA, ILL.
(For the Year ending April 1, 1912.)

	Million Gallons during Year.	Per Cent. of Total.
Through large industrial meters, Champaign	13.7	3
Through large industrial meters, Urbana	75.1	14
Through small domestic meters, Champaign	96.1	17
Through small domestic meters, Urbana	48.2	8
By 641 flat-rate consumers at 600 g.p.d., estimated	110.4	20
By-passed at pumping station	18.0	4
Flush tank consumption	6.7	1
Total water accounted for by consumption and waste	368.2	67
Water-unaccounted-for (=33 per cent. of 550 Mg.)	182.0	33
Total water pumped in 1911	550.0	100

TABLE 48.

DOMESTIC WATER CONSUMPTION PER CAPITA AND PER CONSUMER OR FAMILY IN CHAMPAIGN AND URBANA.
(For the Year ending April 1, 1912.)

Place.	Estimated Population, Including Students.	Number of Domestic Consumers.	Metered Domestic Consumption in Gal. per Day.		
			Total.	Per Consumer.	Per Capita.
Champaign	.....	2 045	263 000	129	....
Urbana	.....	1 201	132 000	110	....
Total	27 600	3 246	395 000	122	15.4

In other words, whereas the average daily pumpage of water amounted to 55 gal. per capita, the actual domestic use of water amounted to but 15 gal. per capita per day.

Similar results are indicated by the following figures for the cities of Des Moines, Ia.; and New Orleans, La.

TABLE 49.

ANALYSIS OF TOTAL PUMPAGE, DES MOINES, IA., FOR YEAR ENDING DECEMBER 31, 1911.
(By courtesy of Mr. C. S. Denman.)

	Million Gallons.	Gallons per Capita per Day. *	Per Cent. of Total Pumpage.
1. Private Consumption:			
a. Metered (including schools and non-municipal public buildings)	1 068.0	32.5	55.4 per cent.
b. Unmetered (about 600 small consumers, estimated)	33.0	1.0	1.7 per cent.
Total	1 101.0	33.5	57.1 per cent.
2. Public Consumption:			
a. Public buildings (other than municipal) (included in 1*a*).			
b. Municipal buildings and engine houses (metered and unmetered)	6.4	0.2	0.3 per cent.
c. Street sprinkling and washing (included in 3*d*).			
d. Snow flushing, estimated	13.0	0.4	0.7 per cent.
e. Sewer flushing (included in 3*d*).			
f. Street construction work (included in 3*d*).			
g. Fire protection (included in 3*d*).			
h. Troughs and fountains (metered and estimated)	50.3	1.5	2.6 per cent.
i. Parks and cemeteries (metered)	9.2	0.3	0.5 per cent.
Total	78.9	2.4	4.1 per cent.
3. Operation Consumption:			
a. Slippage (included in 3*d*).			
b. Flushing mains (included in 3*d*).			
c. Leakage (included in 3*d*).			
d. 2*c*, 2*e*, 2*f*, 2*g*, 3*a*, 3*b*, and unaccounted for	748.1	22.8	38.8 per cent.
Total pumpage	1 928.0	58.7	100.0 per cent.

* Based on an estimated population of 90 000.

TABLE 50.

ANALYSIS OF DAILY CONSUMPTION OF WATER AT NEW ORLEANS, 1911.
(By courtesy of Mr. George G. Earl, superintendent of Water Works.)

	Million Gallons per Day.	Per Cent of Total.
Pay water to paying consumers	8.00	50.0
Free water to paying consumers	2.00	12.5
Under registration, paying consumers meters	1.00	6.3
Water used by free consumers, including 10 per cent. under registration of meters	1.12	7.0
Water used for all purposes at plants	0.20	1.2
Flushing sewers	0.07	0.4
Used through 5 000 fire hydrants for all purposes	2.00	12.5
Balance, leakage	1.61	10.1
Total	16.00	100.0

CONSIDERATIONS GOVERNING RECOMMENDATIONS OF THE COMMITTEE.

While data might be multiplied upon all of the factors suggested herein as influencing water consumption, and others not referred to, such as variation in water pressure, the facts adduced seem to justify a revision of the form for recording water consumption statistics now in use by this Association.

In outlining the suggested new forms, the committee, while recognizing the desirability of further subdivisions of water consumption than those recommended by it, has been constrained by the belief that the form of the record must be made as simple and ready of application as possible, in order to induce operators to make use of it and to analyze the conditions existing upon their works with sufficient care to attain substantial accuracy. In this way only is it believed to be possible to get a number of reports along the new lines sufficient for comparative purposes. Later, when the importance of accurate knowledge of water consumption, use, waste and leakage is more clearly recognized, further subdivision and analysis may prove feasible, as well as desirable.

LEONARD METCALF, *Chairman*,
FRANK J. GIFFORD,
WILLIAM F. SULLIVAN,
Committee.

[Discussion of this Report will be held until after the September meeting for publication with the Proceedings thereof.]

Equivalents of Various Measures.

	U. S. Gallons.	Imperial Gallons.	Liters.	Cubic Feet.	Cubic Meters.	Cubic Inches.	Pounds Avoirdupois (Water at 0° C.).
1 U. S. gallon	1.0	0.8311	3.78543	0.13368	0.003785	231.0	8.34545
1 Imperial gallon	1.20032	1.0	4.54374	0.16046	0.004544	277.274	10.0172
1 Liter	0.26417	0.22008	1.0	0.03531	0.001	61.0234	2.20462
1 Cubic foot	7.48052	6.23210	28.31700	1.0	0.028317	1 728.0	62.4283
1 Cubic meter	264.170	220.083	1 000.0	35.3145	1.0	61 023.4	2 204.62
1 Cubic inch	.....	.....	.....	.....	.....	1.0	0.036128

PROCEEDINGS.

Annual Meeting.

Hotel Brunswick,
Boston, Mass., January 8, 1913.

The President, Mr. George W. Batchelder, in the chair.
The following members and guests were present:

Honorary Members.

F. W. Shepperd and F. P. Stearns. —2.

Members.

S. A. Agnew, Randolph Bainbridge, C. H. Baldwin, A. F. Ballou, F. A. Barbour, H. K. Barrows, G. W. Batchelder, C. R. Bettes, A. E. Blackmer, Dexter Brackett, E. C. Brooks, James Burnie, G. A. Carpenter, J. C. Chase, R. C. P. Coggeshall, W. R. Conard, H. R. Cooper, A. W. Cuddeback, G. W. Cutting, Jr., F. W. Dean, J. C. DeMello, Jr., John Doyle, E. R. Dyer, E. D. Eldredge, J. N. Ferguson, G. H. Finneran, F. F. Forbes, F. L. Fuller, F. J. Gifford, A. S. Glover, F. H. Gunther, R. K. Hale, F. E. Hall, E. A. W. Hammatt, A. R. Hathaway, T. G. Hazard, Jr., Allen Hazen, J. L. Howard, A. C. Howes, J. L. Hyde, H. R. Horton, E. W. Kent, Willard Kent, G. A. King, J. J. Kirkpatrick, C. F. Knowlton, H. O. Lacount, C. A. Leary, Daniel MacDonald, F. A. McInnes, W. A. McKenzie, N. A. McMillen, H. V. Macksey, A. E. Martin, John Mayo, J. H. Mendell, F. E. Merrill, William Naylor, Leonard Metcalf, H. A. Miller, C. E. Peirce, T. A. Peirce, C. M. Saville, C. W. Sherman, M. A. Sinclair, J. W. Smith, G. A. Stacy, W. F. Sullivan, L. A. Taylor, R. J. Thomas, L. D. Thorpe, D. N. Tower, C. H. Tuttle, W. H. Vaughn, J. H. Walsh, F. P. Washburn, R. S. Weston, G. C. Whipple, T. H. Wiggin, F. B. Wilkins, G. E. Winslow. — 81.

Associates.

Builders Iron Foundry, by A. B. Coulters and D. W. Bartlett; Central Foundry Company, by J. H. Morrison; Chapman Valve Manufacturing Company, by R. Shirley and H. L. DeWolfe; Darling Pump and Manufacturing Company (Ltd.), by W. H. Peckersgill; *Engineering Record*, by R. K. Tomlin and I. S. Holbrook; Goulds Manufacturing Company, by R. E. Gould; Hersey Manufacturing Company, by A. S. Glover and W. A. Hersey; Kennedy Valve Company, by Mr. Brosnan; Lead-Lined Iron Pipe Company, by T. E. Dwyer; Chas. Millar & Son Co., by C. F. Glavin; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by C. H. Baldwin, J. G. Lufkin, and H. L. Weston; Neptune Meter Company, by H. H. Kinsey; Pittsburgh Meter Company, by J. W. Turner; Platt Iron

Works Company, by F. H. Hayes; Rensselaer Valve Company, by C. L. Brown and F. S. Bates; Standard Cast Iron Pipe and Foundry Company, by Wm. Woodburn; Union Water Meter Company, by F. E. Hall; United States Cast Iron Pipe and Foundry Company, by D. B. Stokes; Water Works Equipment Company, by W. H. Van Winkle, Jr.; R. D. Wood & Co., by H. M. Simons; Henry R. Worthington, by Samuel Harrison; A. P. Smith Manufacturing Company, by D. F. O'Brien. — 30.

GUESTS.

Milton Thorne, Portland, Me.; R. Suter, Albany, N. Y.; Master James Kintoch, East Greenwich, R. I.; M. L. Fuller, Brockton, Mass.; Frank I. Hall, Middletown, Conn.; Ivers M. Low, Weymouth, Mass.; J. Griffin, Middletown, Conn.; Professor Carpenter, Ithaca, N. Y.; Charles R. Gow, Boston, Mass.; and D. J. Higgins, Waltham, Mass.; Mr. Grove and Mr. Marks, of Washington, D. C. — 12.

The Secretary read the records of the December meeting, and they were approved.

The Secretary presented applications for active membership, properly endorsed and recommended by the Executive Committee, from Milton Thorne, Portland, Me., engaged in construction work, Portland Water District; Russell Suter, Albany N. Y., with the New York State Water Supply and Conservation Commission; John S. Potter, State Highway Commission of Minnesota, assistant engineer at large; Richard Winslow Sherman, Utica, N. Y., chief engineer New York State Conservation Commission; J. C. Rickards, Canton, N. C., superintendent Canton Water Works; John D. Moore, with the New York State Conservation Commission.

On motion of Mr. Edwin C. Brooks, the Secretary was directed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

The Secretary, Mr. Willard Kent, presented his annual report as follows:

REPORT OF THE SECRETARY.

JANUARY 1, 1913.

Mr. President and Gentlemen of the New England Water Works Association, — In accordance with the Constitution, the Secretary submits herewith the following detailed statement of the changes in membership in the several grades for the past year.

MEMBERSHIP.

January 1, 1912.	Honorary Members	12			
January 1, 1913.	Honorary Members				12
January 1, 1912.	Total Members		680		
	Withdrawals:				
	Resigned	23			
	Dropped	30			
	Died	9	62		
		—	—	618	
	Initiations:				
	January	6			
	February	10			
	March	2			
	June	10			
	September	5			
	November	2			
	December	4			
		—	39		
	Reinstated:				
	Nine members reinstated in 1912		9	48	
			—	—	666
January 1, 1912.	Total Associates		58		
	Withdrawals:				
	Resigned	4			
	Dropped	4	8		
		—	—	50	
	Initiations:				
	March	1			
	September	2		3	53
January 1, 1913.	Total membership				731

The Secretary has received $6 650.89, which has been paid to the Treasurer, and has certified for payment, bills amounting to $4 463.10.

There is due the Association at this date —

For Reprints	$5.25
,, JOURNALS	8.00
,, Advertisements	53.75
,, Standard Specifications	7.20
Total	$74.20

I know of no outstanding bills against the Association other than those for the December issue of the JOURNAL not yet presented.

A statement of the receipts, expenditures, accounts receivable, and bills payable will be found in detail in the report of the Treasurer.

Respectfully submitted,

WILLARD KENT, *Secretary.*

Year.	President.	Membership at End of Year.				Annual Convention.		Receipts.	Expenditures.	Cash Balance.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 271.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	*Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	†4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	‡2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	†4 566.84	‡3 449.57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	†7 237.60	‡2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	†6 279.72	‡2 880.23
1912	Geo. W. Batchelder	666	53	12	731	Washington, D. C.	Sept. 18–20, '12	6 861.65	†5 934.56	‡3 807.32

* Deceased.

† Not including December JOURNAL and reprints.

‡ Does not include $1 815 invested in bonds.

MR. R. C. P. COGGESHALL. Do I understand from the report that during the past year there has been a net loss in the membership?

THE SECRETARY. A year ago the total membership was 750, and to-day it is 731.

MR. COGGESHALL. That is, we are 19 shy from a year ago?

THE SECRETARY. Rather more than the usual number, I think, have withdrawn by resignation during the year, and 30 members have been dropped.

MR. COGGESHALL. In preceding years we have usually shown a small gain each year?

THE SECRETARY. We have usually shown a small gain.

On motion of Mr. Coggeshall it was voted that the report of the Secretary be accepted, placed on file, and printed in the JOURNAL.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$214.11
Initiation fees	$197.00	
Dues	2 866.50	
Total received from members		3 063.50
JOURNAL:		
Advertisements	$1 838.75	
Subscriptions	213.00	
Sale of JOURNALS	266.19	
Sale of Reprints	149.80	
Total received from JOURNAL		2 467.74
Miscellaneous receipts:		
Sale of "Pipe Specifications"	$40.90	
Dinners	670.50	
June Excursion	404.90	
Total miscellaneous receipts		1 116.30
Total receipts		$6 861.65

Expenditures.

JOURNAL:			
Advertising agent, commission		$250.00	
Plates		70.97	
Printing		1 215.11	
Editor's salary		300.00	
Expense		30.99	
Reporting		265.10	
Reprints		197.25	
Envelopes		28.50	
			$2 357.92
Office:			
Secretary, salary		$250.00	
Expense		62.82	
Assistant Secretary, salary		600.00	
Expense		159.11	
Rent		500.00	
Printing		65.50	
Membership lists		191.00	
Stationery		94.22	
Envelopes and postage		113.50	
Library		6.50	
Miscellaneous		6.75	
			2 049.40
Meetings and Committees:			
Stereopticon		$50.50	
Dinners	$689.00		
Cigars	46.30		
Music	75.00		
		810.30	
Badges		47.39	
Printing and postage		159.75	
			1 067.94
Treasurer's salary and bond			67.50
June Excursion			373.00
Miscellaneous expenses			18.80
			$5 934.56

On motion of Mr. Edwin C. Brooks, it was voted that the report of the Treasurer be accepted, placed on file, and printed in the JOURNAL.

LEWIS M. BANCROFT, TREASURER,
In account with the New England Water Works Association.

RECEIPTS.		EXPENDITURES.		
1912.				
Jan. 1. Balance on hand	$2 880.23	Bills paid		$5 934.56
Received of Willard Kent, Sec'y	6 650.89	BALANCE ON HAND.		
Interest on bonds and deposits	210.76	People's Savings Bank	$1 950.28	
		Mechanics Savings Bank	1 014.98	
		First National Bank	607.52	
		Liberty Trust Co.	234.54	
				3 807.32
	$9 741.88			$9 741.88

ASSETS AND LIABILITIES.

ASSETS.			LIABILITIES.	
Cash, balance in banks		$3 807.32	Accounts payable:	
Bonds Nos. 2642 and 2644 Lake Shore & Mich. So. R. R. 4%, due May 1, 1931. Book value, $1 815. Market value		1 850.00	Editor's salary	$75.00
Accounts receivable:			Reprints	55.75
Reprints	$5.25		Plates	59.17
JOURNALS	8.00		Printing	77.00
Advertising	53.75			$266.92
Specifications	7.20		Surplus	5 464.60
		74.20		
		$5 731.52		$5 731.52

READING, January 7, 1913.

LEWIS M. BANCROFT, *Treasurer.*

The Editor, Mr. Richard K. Hale, submitted the following report:

Report of the Editor.

Boston, January 8, 1913.

To the New England Water Works Association, — I present the following report for the Journal of the New England Water Works Association for the year 1912.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of the Journal for the past year (including the cost of the December Journal and reprints, bills for which were received too late to pay in 1912, and which are consequently not included in the Treasurer's statement); and a comparison with the conditions of preceding years.

Size of Volume. — The volume is somewhat smaller in total pages and pages of text than that of several preceding years.

Illustrations. — The total cost of illustrations for the year, including printing, has been $249.64, or 10 per cent. of the gross cost of the volume.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge, and additional reprints, when desired, at the cost of the paper and press work. The net cost to the Association for reprints has been $91.45. There have been advance copies of four papers prepared during the year at a cost of $35.50.

Circulation. — The present circulation of the Journal is:

Members, all grades	731
Subscribers	69
Exchanges	26
Total	826

a decrease of 14 over the preceding year. Journals have also been sent to 48 advertisers.

Advertisements. — There has been an average of 25 pages of paid advertising, with an income of $1 731.25, a slight decrease over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $40.90 have been sold; none were printed during the year. The net gain up to a year ago had been $214.05, so that the total net gain from this source to date is $254.95. There are still about 113 copies of specifications on hand, or about $11.30 worth if sold at retail.

The Association has a credit of $4.09 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the Journal at pound rates.

There are no outstanding bills, on account of the Journal, which are not included in these tables.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XXVI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1912.

Number.	Date.	Pages of									Total Cuts.
		Papers.	Proceedings.	Total Text.	Membership Changes.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total.	
1	March	59	53	112	..	..	30	4	2	148	8
2	June	55	5	60	..	..	30	4	6	100	13
3	September	114	18	132	2	..	30	4	4	172	6
4	December	90	7	97	..	6	30	4	10	147	26
	Total	318	83	401	2	6	120	16	22	567	53

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXVI, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1912.

Receipts.		*Expenditures.*	
From advertisements	$1 731.25	For printing JOURNAL	$1 162.95
From sale of JOURNAL	266.19	For printing illustrations	119.50
From sale of reprints	167.30	For preparing illustrations,	130.14
Subscriptions	213.00	For editor's salary	300.00
	$2 377.74	For editor's incidentals	37.86
Net cost of JOURNAL	98.81	For advertising agent's commissions	246.25
		For adv. agent's incidentals	2.00
		For reporting	183.60
		For reprints	258.75
		For advance copies	35.50
	$2 476.55		$2 476.55

TABLE No. 3.

Comparison between Volumes XVIII to XXVI, Inclusive, Journal of the New England Water Works Association.

	Vol. XVIII. 1904.	Vol. XIX. 1905.	Vol. XX. 1906.	Vol. XXI. 1907.	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XXIV. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.
Average edition (copies printed)	900	900	900	1 085	1 000	1 000	1 150	1 000	1 000
Average membership	596	625	665	693	699	710	732	752	740
Circulation at end of year	667	705	767	785	780	802	827	840	826
Pages of text	491	587	495	500	500	459	643	475	401
Pages of text per 1 000 members	824	939	745	722	715	646	880	632	542
Total pages, all kinds	794	784	662	669	681	627	808	654	567
Total pages per 1 000 members	1 332	1 254	995	964	976	884	1 090	870	766
Gross Cost:									
Total	$2 928.77	$3 266.65	$2 573.61	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55
Per page	3.69	4.17	3.88	3.95	4.01	4.97	4.32	4.02	4.37
Per member	4.91	5.23	3.87	3.82	3.91	4.39	4.78	3.50	3.35
Per member per 1 000 pages	6.18	6.67	5.85	5.70	5.88	7.00	5.90	4.09	5.90
Per member per 1 000 pp. text	10.00	8.91	7.81	7.62	8.02	9.56	7.44	7.36	8.35
Net Cost:									
Total	$648.11	$1 072.95	$387.96	$483.15	$131.06	$789.98	$1 334.06	$352.82	$98.81
Per page	.82	1.37	.58	.72	.19	1.26	1.65	.54	.17
Per member	1.09	1.72	.58	.70	.19	1.11	1.82	.47	.13
Per member per 1 000 pages	1.30	2.20	.88	1.04	.28	1.78	2.25	.55	.23
Per member per 1 000 pp. text	2.22	2.93	1.18	1.39	.39	2.43	2.83	.98	.33

On motion of Mr. R. C. P. Coggeshall, it was voted that the report of the Editor be accepted and printed in the JOURNAL.

REPORT OF THE AUDITING COMMITTEE.

The Auditing Committee submitted the following report:

BOSTON, MASS., January 7, 1913.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

ALBERT L. SAWYER,
JOHN W. MORAN,
Auditing Committee.

On motion of Mr. E. C. Brooks, it was voted that the report of the Auditing Committee be accepted, placed on file, and printed in the JOURNAL.

REPORT OF COMMITTEE TO PREPARE A STANDARD SPECIFICATION FOR FIRE HYDRANTS.

JANUARY 8, 1913.

To the New England Water Works Association, — As suggested at the January, 1912, meeting of the Association, the committee arranged for a conference with the manufacturers, and to this conference the committee from the American Water Works Association, also the National Fire Protection Association, were invited. The meeting was held on May 8, and all of the parties above mentioned were represented with the exception of the American Water Works Association.

An agreement was reached on most of the points under discussion, but regarding the matter of the size of the valve opening, the manufacturers considered that more data as to the friction losses in present commercial hydrants should be obtained than was available from the tests which the committee had made during the previous year on the few hydrants which they had been able to get from outside sources.

The manufacturers agreed to furnish such hydrants as the committee desired for this further work, and later a list of hydrants was prepared which it was considered would represent the present commercial product.

Excellent testing facilities were arranged for by Mr. F. A. McInnes, a member of the committee, and the tests were carried out during the fall. Five manufacturers furnished sample hydrants, three of each make.

The working up of the data for the tests of these fifteen hydrants, however,

has but just been completed, and not in time to be considered by the committee in conference with the manufacturers before this meeting of the Association.

A final conference of the several committees previously mentioned and the manufacturers is to be called soon, after which the committee will be ready to report its final conclusions to the Association.

It is believed that some headway has been made during the past year, and, therefore, this report is to-day submitted as one of progress.

Respectfully,

H. O. LACOUNT, *Chairman.*

THE PRESIDENT. If there is no objection on the part of the members present, we will continue the committee. It seems to be doing good work. Next is the report of the Committee "to Look After and Keep Track of Legislation and Other Matters Pertaining to the Development and Utilization of the Natural Resources of the Country." Mr. M. N. Baker is chairman of the committee. Is there any one here who represents the committee?

THE SECRETARY. Mr. Baker writes that he cannot be present at the annual meeting and asks that I submit to the Association the following report:

REPORT OF THE COMMITTEE "TO LOOK AFTER AND KEEP TRACK OF LEGISLATION AND OTHER MATTERS PERTAINING TO THE CONSERVATION, DEVELOPMENT, AND UTILIZATION OF THE NATURAL RESOURCES OF THE COUNTRY."

Your committee has nothing to report on its own behalf. It transmits, for such action as the Association sees fit, a letter from Mr. Gifford Pinchot, written on the letterhead of the National Conservation Association, urging the New England Water Works Association to define its position as to an attempt which Mr. Pinchot says is being made to transfer ownership of the national forests of the United States to the several states.

I may add that your committee has not conferred on the subject, so the only opinion I can express is the personal one that the transfer would be a national misfortune. If the other members of the Association are of like opinion it would seem to be desirable (again speaking personally) for the Association to pass a resolution against the transfer and to send copies of the resolution to the persons mentioned at the close of Mr. Pinchot's letter.

M. N. BAKER, *Chairman.*

DECEMBER 31, 1912.

NEW ENGLAND WATER WORKS ASSOCIATION,
Mr. M. N. BAKER, 220 BROADWAY, NEW YORK, N. Y.

My dear Sir, — I realize, at least in part, how great must be the pressure of current work before your organization. But in the light of the work your organization has done and is doing, and of the standards which govern it, I believe that the request that I am about to make will not be disregarded.

For several years a movement has been afoot to turn the national forests over to the states. This movement is now alert, organized, and active, and notice has been served in Congress that it will be pushed. Behind the movement are interests like the water power combines, eager to get public resources into their own hands for their own unregulated use, and which see no other way of accomplishing this result except by the easy road of state ownership and administration.

I need not say to you that once such a movement is afoot in Congress, it is a pressing danger until it has been met and overcome. I look upon the danger of the transfer of the national forests to the states as decidedly the most serious that has yet confronted the conservation movement.

There are two reasons against state ownership or state administration of national forests. The one is that it is impracticable upon the side of efficiency; the other is that it would make extremely difficult the protection of the national forests from graft.

The national forests, like the water powers, the timber, the grass, and the coal measures which they contain, are all resources essential to the national prosperity. They do not stop, and the use of them does not stop, at state lines. They can be used and developed and administered only under a central policy alive to their importance to the whole people, and not sensitive merely to their importance to any one section of the people. On the side of expense, state administration of the national forests would necessarily entail the greatly increased difficulty and cost of creating and maintaining many forest services instead of maintaining a single National Forest Service, and national forest users would pay the enormously multiplied cost. And it is well to remember that the time is rapidly coming when the products of the national forests will be little less important to those who live in the North and in the South than to those who live in the West. This is as true of beef and mutton, grazed in the forests, as it is of wood.

But the chief danger of this movement to turn over the national forests to the states is that under state ownership national forest resources, like water power, timber, and the land itself, would pass rapidly into unregulated private ownership and control. The best evidence of this danger is the story of how the Western states have administered their public lands; and there is a similar record in many Eastern states as well. Two billion dollars' worth of tangible resources, which is what the national forests are easily worth, offers large opportunities and large attractions to the grabbers. That is the chief danger of the movement to turn the national forests over to the states.

What I am led to ask is that your organization make its position clear in

this fight. You will know best how this might be done. If there is any way in which the attempt to break down the national forest system and the national conservation policy can be brought to the attention of your members, then I earnestly ask that this be done. It may be possible also for your organization to take up this matter in a resolution protesting against the proposed transfer to the states, a copy of which resolution might well go to the President, the presiding officer of the Senate, the Speaker of the House, as well as Senators and Representatives in Congress. Such action would be helpful in the highest sense in protecting the natural resources for all the people.

Sincerely yours,

GIFFORD PINCHOT.

THE PRESIDENT. This report by Mr. Baker shows progress, but is not final. If there is no objection the committee will be continued. Is there anything to be said about Mr. Pinchot's letter?

MR. J. WALDO SMITH. Mr. President, on a great many matters I am not at all in accord with Mr. Pinchot, but I do agree with him on this. It seems to me it would be a great mistake, and, perhaps, a great public misfortune, to have the public forest lands, now under the control of the government, split up and transferred to the various states. Such a thing could result only in divided responsibility, and, I believe, in a much less efficient administration. I would move that this matter be referred back to the committee with power to act, with the further statement that it is the sense of this meeting that the best interests of the people will not be served by a transfer of these forest lands to the states.

MR. C. E. PEIRCE. It seems to me, Mr. President, that a resolution coming directly from the Association would be more effective than merely the action of the committee.

MR. SMITH. I will add to my motion that the committee be requested to draft a resolution to be reported back to the Association at the next meeting.

MR. PEIRCE. That would meet my idea.

Mr. Smith's motion as amended was adopted.

THE PRESIDENT. Report of Committee on "Water Consumption and Statistics Relating Thereto." Mr. Leonard Metcalf is chairman of that committee.

Report of Committee on Water Consumption and Statistics Relating Thereto.

Mr. Leonard Metcalf. The report of the committee is substantially in shape. It is, however, too long a document to present to the Association at this time, and the committee has, therefore, suggested to the Executive Committee that, if it deems the matter of sufficient interest to members of the Association, the report be assigned for discussion at some future meeting. The committee hopes that advance copies of this report will be prepared and sent out, and that members may find time to give the subject careful consideration, and that all who can will contribute to the data contained in the report, so that it may in fact be a symposium upon this subject.

We feel that we have been very fortunate in getting together certain data, as a result of the good-will and the courtesy of a number of different gentlemen who have contributed, particularly Mr. Brackett, who has given us some of the Metropolitan records which we think extremely valuable, and which have not yet appeared in print, at all events in the form in which they will appear in this report. Some of the tabulations which have resulted from the data submitted by the various members in answer to the circular which we sent out also give good new material. We hope that all of you will do what you can to fill in any missing places that you may find in the report.

The President. You have heard Mr. Metcalf's remarks, gentlemen, and if there is no objection I think it will be well to continue the committee until such time as the report is presented to the Association. Hearing no objection we will let the matter stand in that way.

Next is the report of the Committee "to Collect Information as to Low Water Yields of Catchment Areas in New England, and, at their Discretion, Outside of New England." Mr. Frederic P. Stearns is chairman of that committee.

Report of Committee to Collect Information as to Low Water Yields of Catchment Areas in New England, and, at their Discretion, Outside of New England.

Mr. Frederic P. Stearns. The committee has written this letter to the Secretary, which I will read:

January 7, 1913.

Mr. Willard Kent, *Secretary*,
New England Water Works Association,
715 Tremont Temple, Boston, Mass.

Dear Sir, — In its progress report dated September 14, 1912, the Committee on Yield of Drainage Areas expressed the hope that it might present its final report at the annual meeting in January, and it regrets that it is unable to do so.

Information regarding the yield of several additional streams for the years 1908–1911 inclusive has been received since September, completing all of the returns which the committee expects to receive, but four of these were received since the first of January, making it impracticable to report at the annual meeting.

Much work has been done since we last reported in working up the data received, and the necessary additional work will be done and a report prepared as promptly as possible.

Very truly yours,
FREDERIC P. STEARNS, *Chairman*.
H. K. BARROWS, *Secretary*.

I might add that since coming here I have been promised one more return which will be ready within a week, and the committee intends to close the matter up and bring things to a head at once.

The President. You have heard the report as presented by Mr. Stearns. If there is no objection the committee will be continued until such time as its final report is ready. The chair hears no objection.

Report of Committee on "Standard Specification of Cast-Iron Pipe." Mr. F. A. McInnes is chairman of the committee.

Report of Committee on Standard Specification of Cast-Iron Pipe.

The Secretary. Mr. McInnes is unable to be present and has sent the following letter, which I will read:

BOSTON, MASS., January 8, 1913.

To the President and Members of the New England Water Works Association, — I beg to report on behalf of the Committee on Standard Specifications for water pipe that sufficient progress has not yet been made to warrant a detailed report at this time; we have made a good start and hope for substantial progress in the near future.

Very respectfully,

F. A. McINNES, *Chairman*
Committee on Standard Specifications for Water Pipe.

THE PRESIDENT. You have heard this report. I know from personal knowledge that the committee is doing valuable work, which takes a good deal of time. If there is no objection we will continue the committee with power until it is ready to present its final report.

The Secretary read the following letter:

BOSTON, January 8, 1912.

NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — Following the cold winter of 1911–12, President Batchelder suggested that the committee which had previously reported on the Depth of Laying Water Pipe might profitably seek to obtain additional data.

Accordingly, in March, 1912, the undersigned sent out seventy personal letters to superintendents and engineers located in parts of this country and Canada where it was believed that the conditions of the preceding winter might have developed interesting results.

Forty replies were received, but no information tending to change the earlier conclusions of the committee,* namely, that freezing in mains laid at the depth now generally adopted has not occurred, except in dead ends, and that where there is an assured circulation, depths somewhat less than present practice would be safe.

Respectfully submitted,

F. A. BARBOUR, *Chairman.*

Mr. Charles W. Sherman, principal assistant with Metcalf & Eddy, Boston, Mass., presented a paper entitled "An Experience with Water-Ram." Mr. Caleb M. Saville followed with a paper relating experience with water-ram which he had had in connection with the Hartford works. The subject was discussed by Mr. G. A. Caldwell, Mr. Francis W. Dean, Mr. John Doyle, Mr. Allen Hazen, Mr. Frank L. Fuller, and Mr. Charles E. Peirce.

Mr. Robert J. Thomas, superintendent, Lowell, Mass., read

* JOURNAL N. E. W. W. A., Vol. 23 (1909), p. 435.

a paper on "The Water Works of the City of Lowell and Some Recent Improvements," illustrated by stereopticon views.

Mr. Batchelder, the retiring President, then made his address.

President's Address.

Gentlemen of the New England Water Works Association, — The time has arrived when your retiring President is to render an account of the affairs of the Association for the year 1912.

The reports of other officers so completely cover the ground there is little left for the President to say.

The year just closed has been typical of many others. Meetings have been held at the Brunswick Hotel during the months of January, February, March, November, and December.

The June outing of the Association took the form of a trip to the Cape Cod Canal, and was attended by 133 members and guests. A special train conveyed the party to Buzzard's Bay, where a part of the work could be seen, and the project was explained by one of the engineers in charge. Special electric cars were taken to Onset, where luncheon was served, after which the return trip to Buzzard's Bay carried the party to their special train which conveyed them to several stopping places where work was in progress. The trip back to Boston was a quick one, with hardly a stop, and brought to a close what was to the writer a delightfully cool and pleasant day.

The Annual Convention was held in Washington, D. C., September 18, 19, and 20, headquarters at the Congress Hall Hotel. There was a registration of 221 members and guests.

Several papers were read and discussed relating principally to the supervision and control of dams both in construction and operation. These papers were of great interest and treat of a subject which must be recognized as of great importance. The accommodations at the hotel were very satisfactory, the management showing an unfailing desire to please.

The following members have died during the year: C. A. Allen, December 9, 1912; T. C. Bates, January 11, 1912; D. S. Brinsmade, September 7, 1912; N. W. Hayden, January 29, 1912; G. A. Kimball, December 3, 1912; D. S. Merritt, March 8, 1912;

J. B. Putnam, May 8, 1912; Ulrich Taubenheim, January 8, 1912; C. K. Walker, September 9, 1912.

Former presidents of your Association have chosen many subjects for their addresses, so that the field for originality is narrowed. The subject of my brief paper to you to-day is, "The Public in Connection with the Administration of a Water Department."

In the development of water supplies great difficulties have to be overcome. To secure necessary appropriations often requires years of hard work and courage in the face of opposition, which frequently, through lack of knowledge of the conditions, succeeds in delaying work which is badly needed.

After appropriations are made the work progresses and in many cases a fine plant is put in operation, reservoirs of ample storage capacity are constructed, containing a supply of excellent water, a good pipe system is laid, the water rates are reasonable, and good service is given the consumers; but if the element of human interest is left out in the relations between the public and the management, the highest degree of efficiency cannot be attained.

The citizens of this country, as well as others, have an inborn doubt as to the fairness of public service corporations and municipal departments.

Who among us has not heard some story about the gas company, for instance, — how the owner's house was closed for weeks and a bill rendered him just the same, etc.

We have undoubtedly heard many worse ones about the departments we manage, and it sometimes appears as though many men think a bill rendered by a municipal department is either made larger than circumstances warrant or is downright robbery.

The best way to overcome that difficulty has been studied by the writer for several years, and it sometimes appears that study might go on forever, there constantly being a new crop of kickers born, but good results are worth hard work, and if advances are made, that gives sufficient encouragement to keep on.

To secure the confidence of the consumer is, in the writer's opinion, the key to the whole situation, and no better way can be found than by giving close personal attention to all complaints

and dealing with each one with perfect frankness. Attempts to fool the public are wrong in principle and poor in policy.

Every person who has a complaint to make about the service, a bill which has been rendered, or of anything in connection with the department, should be accorded a hearing, listened to courteously, and the matter carefully looked over.

If the consumer has a just complaint it should be fairly and promptly adjusted; if there is no mistake or fault in the service, an examination will reveal that fact, and the explanation will be satisfactory. This paper is intended to deal with the man who thinks he has cause for complaint, — not the dishonest man who wants something for nothing, or the bluffer who thinks a loud voice will win him something. There are other ways of treating people of that sort.

The most frequent cause of complaint against a water department is in the amount of the bill rendered for water at certain stated periods, and the writer asks the liberty of citing some of the things done in Worcester to satisfy or at least show a desire to look after the consumer's interests.

The water meters in Worcester are read monthly, each day's readings put on cards which are left in the office every morning. These readings are carefully gone over, an increase of ten to twenty per cent. over the previous reading is noted, and an inspector is dispatched to the premises.

His duty is to make an inspection of the fixtures to see if any leaks are in existence, and to go thoroughly over the whole proposition with a view of discovering the reason of the increase in the meter readings.

The detailed method of looking for leaks is, of course, familiar to you all and needs no explanation here.

When leaking fixtures are discovered, the owner receives a notice from the water office stating the nature and location of the leak, the amount of water being consumed, and he is advised to have the leak promptly repaired.

In case no leak is found, there may be other reasons why the consumption of water is excessive; if these can be discovered by the inspector, a report is made to the owner, and if no reason can be found, the owner is notified of the excessive use so he will be

aware of what is going on. Now, how does this work out? The fair-minded person when made to feel that his interests are being looked after, especially by a municipal department, is surprised and gratified. The man who would adopt sharp practice and seek a reduction in his water bill makes a very poor showing when confronted by evidence that continued and neglected leaks of which he had been notified were the cause of his large bill. The case of one large property owner will illustrate this point.

He had repeatedly been notified of a leaking water closet and had allowed it to continue for several months, with the inevitable result, a large water bill, amounting in this case to about $45 for a small two-family house. When the bill was rendered, and after waiting to the last day of grace, he called at the office and requested an abatement, which was refused, and the reasons given. He became abusive, but that seemed to have no effect, so he went on his way. Some days afterwards a call came from the mayor's office, and in answering that summons the writer met the gentleman with the large water bill. The mayor said the gentleman had a grievance and had appealed to him. The records were sent for and shown to his Honor, who without hesitation turned and said, "Mr. ————, you haven't a leg to stand on." So the appeal fell flat.

Another phase of the matter and the final chapter in the story came on the writer's way back to the department offices. He was accosted in a suggestive manner by the owner of the property, who in a voice scarcely above a whisper said, "Isn't there some way we can fix that up?" The writer replied in like voice and manner, "Yes." Whereupon the owner said, "How?" and he was told in good round English to "Go to the treasurer's office and pay the bill," which seemed to displease him greatly, as his manner and language immediately lost their calmness.

The practical result of the close observance of meter readings has been to completely change conditions in the Water Department offices after the water bills have been sent out.

Instead of crowds of people in the lobby, waiting to make complaints, listening to the other fellow's story, comparing notes, and knowing all that can be explained before reaching their own case, there is now hardly a ripple; occasionally some misguided mortal

who imagines he has been overcharged, wanders into the office, but his complaint is very mild and he is easily shown the error of his ways.

Requests for abatements have become infrequent and seldom have much kick back of them.

But the chief value of this system consists in educating the people up to the idea that the Water Department means to be fair and is making every reasonable effort to protect the interests of the water takers.

Care must be taken, of course, to prevent the easy-going customer from placing his complete interests in the hands of the municipality and expecting he need make no effort to look after his own affairs, and of course such individuals can be found.

Efforts are also made to look after all complaints of any nature whatever, and in the writer's opinion the expense incurred is a good investment.

Complaints are received at times about the condition of the water, and they should be carefully attended to.

It is the practice in Worcester to flush out the main pipes, through hydrants, in a systematic manner, this being especially true when dead ends occur, but notwithstanding this system, there are frequent complaints of bad water, which are attended to promptly and a special blowing out given.

One case in particular comes to the mind of the writer which shows the other side of the question. A lady whose property is located on a dead-end pipe line was frequent in her complaints of bad water, and the department cheerfully responded to her requests to have the line blown out, until one day in the hearing of one of the clerks in the Water Department she made the remark that "when the wind blew from the east the water at her house was always bad the next day, and she requested the department to blow out the water pipe."

Inasmuch as her home is located over nine miles from the reservoir and on the end of a large pipe line which would not be drawn out for several days, the writer did not respond enthusiastically to her next request.

But we find the general rule that close personal attention to complaints results in a good feeling between the department

and the consumers and is well worth all the time and expense involved.

In conclusion, gentlemen, let me thank you for the many courtesies shown me in the past year and for the honor of having served as your President.

The tellers appointed to canvass ballots submitted the following report:

ELECTION OF OFFICERS.

Whole number of ballots	305
Blank	1

President.

J. WALDO SMITH	294
Scattering	1

Vice-President.

FRANK A. MCINNES	291	CALEB M. SAVILLE	293
LEONARD METCALF	295	SAMUEL A. AGNEW	292
WILLIAM F. SULLIVAN	292	Scattering	1
MILLARD F. HICKS	291		

Secretary.

WILLARD KENT	296

Treasurer.

LEWIS M. BANCROFT	294

Editor.

RICHARD K. HALE	297

Advertising Agent.

GEORGE A. KING	298

Additional Members of Executive Committee.

GEORGE A. STACY	296
JAMES L. TIGHE	295
JAMES W. BLACKMER	295

Finance Committee.

ALBERT L. SAWYER	295
JOHN W. MORAN	293
JOHN C. CHASE	295
Scattering	1

Respectfully submitted,

GEORGE H. FINNERAN.
ARTHUR F. BALLOU.

Addressing Mr. Smith, the newly elected President, the retiring President said: " You having been elected President for the year 1913, allow me to congratulate you and the Association on your election."

Mr. Smith then took the chair and said: Allow me to congratulate our retiring President on the completion of a very successful administration.

Friends and members of the New England Water Works Association, I thank you for this great and unexpected honor. To be frank with you at the start, I want to say that I have coveted this job for a long time, and I am now experiencing the joy which always comes with accomplishment. Born and brought up in Massachusetts, one of the older members of the Association, I think I may say, although I have wandered abroad and fed in strange pastures, I am glad to come home and to be one of you again.

This Association, the oldest of its kind, I think, can look back on many years of effective and successful work. It has been from the start essentially an association of water-works superintendents, — hard-headed, practical men, with an unusual endowment of good judgment, who have learned what they knew from personal, intimate contact with their work. In these days of specialization and more intricate conditions, the engineer has come in to help, but the Association is to-day, as it always has been, essentially one of water-works superintendents. And I am particularly pleased that I can qualify from that standpoint, perhaps not from my present work, but from past experience, — first at Lincoln, Mass., as fireman and engineer, in the repair gang, in the operating force, and later in Paterson, N. J., and I hope, if my good fortune continues, that I will again join the operating and maintenance force.

With the cordial and earnest coöperation of the officers and members of the Association it will be my aim during the coming year to maintain and advance the high standard which my predecessors have set. I thank you, gentlemen. [*Applause.*]

On motion of Mr. Coggeshall it was voted to adjourn.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at the rooms of the Association, Tremont Temple, Boston, Wednesday, January 8, at 11.30 A.M.

Present: President George W. Batchelder, and members J. Waldo Smith, Randolph Bainbridge, Lewis M. Bancroft, Richard K. Hale, George A. King, and Willard Kent.

Six applications for membership were received, viz.: Milton Thorne, Portland, Me.; Russell Suter, Albany, N. Y.; John S. Potter, assistant engineer, State Highway Commission, St. Paul, Minn.; Richard Winslow Sherman, chief engineer, New York State Conservation Commission, Albany, N. Y.; J. C. Richards, Canton, N. C.; John D. Moore, Conservation Commission of the State of New York, Albany, N. Y., and the applicants were by unanimous vote recommended for membership.

A letter from Mr. Gifford Pinchot, with reference to conservation legislation, was presented, and Mr. J. Waldo Smith was instructed to present a motion at the meeting of this Association to the effect that the Committee of this Association on Conservation be duly authorized to act in the matter.

Adjourned.

WILLARD KENT, *Secretary.*

EXCHANGE LIST.

School of Mines Quarterly,
Columbia University Library, New York, N. Y.

The Surveyor,
24 Bride Lane, Fleet St., London, E. C., England.

La Technologie Sanitaire,
115 Rue Joseph II, Brussels, Belgium.

The British Association of Water Works Engineers,
54 Parliament St., Westminster, S. W., London, England.

Professional Memoirs,
Washington Barracks, D. C.

The North of England Institute of Mining & Mechanical Engineers
Newcastle-on-Tyne, England.

United States Patent Office,
Scientific Library, Washington, D. C.

Library Massachusetts Institute of Technology,
491 Boylston St., Boston.

Editor, Journal of the Franklin Institute,
Philadelphia, Pa.

Yale Scientific Monthly,
New Haven, Conn.

Kansas Quarterly,
Lawrence, Kan.

American Society of Civil Engineers,
220 West 57th St., New York, N. Y.

L'Hygiène Général & Appliquée,
8 Place de l'Odéon, Paris, France.

Journal of the Western Society of Engineers,
1737 Monadnock Block, Chicago, Ill.

The Engineering Magazine,
140 Nassau St., New York, N. Y.

Municipal Journal,
50 Union Sq., New York, N. Y.

Municipal Engineering,
Indianapolis, Ind.

Engineers' Society of Western Pennsylvania,
Pittsburgh, Pa.

Central States Water Works Association,
Mr. R. P. Bricker, Sec'y, Shelby, Ohio.

Boston Society of Civil Engineers,
715 Tremont Temple, Boston.

American Society of Mechanical Engineers,
29 West 39th St., New York, N. Y.

Canadian Engineer,
62 Church St., Toronto, Can.

Engineering & Contracting,
308 S. Dearborn St., Chicago, Ill.

Mr. F. W. Frost,
Engineering News Publishing Co., 505 Pearl St., New York, N. Y.

Mr. J. M. Goodell, Editor,
Engineering Record, 239 West 39th St., New York, N. Y.

Illinois Water Supply Association,
Edward Bartow, Sec'y, University of Illinois, Urbana, Ill.

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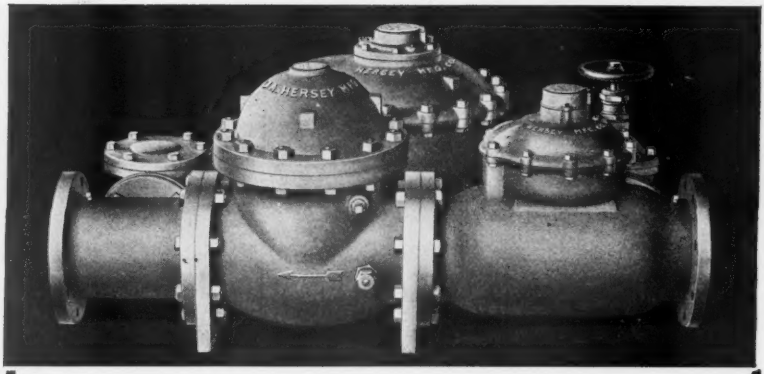

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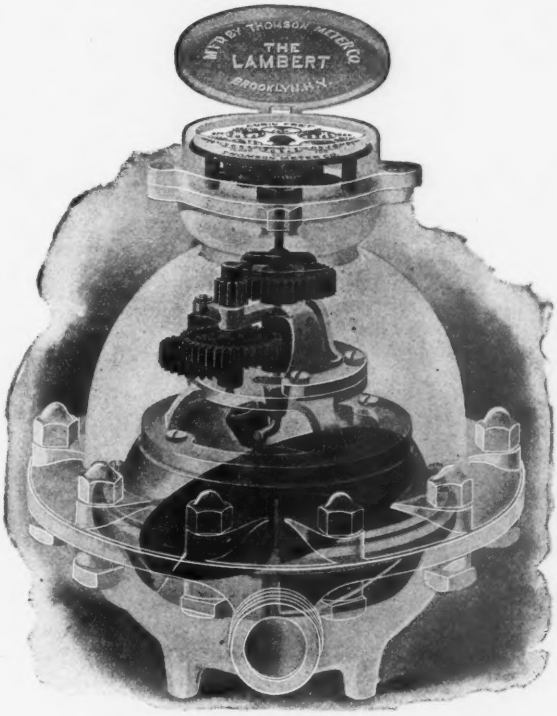

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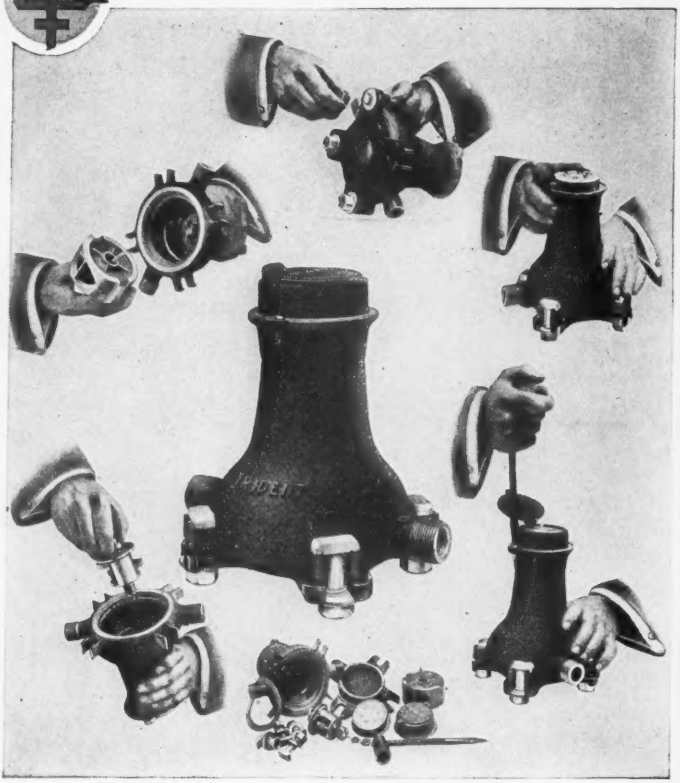

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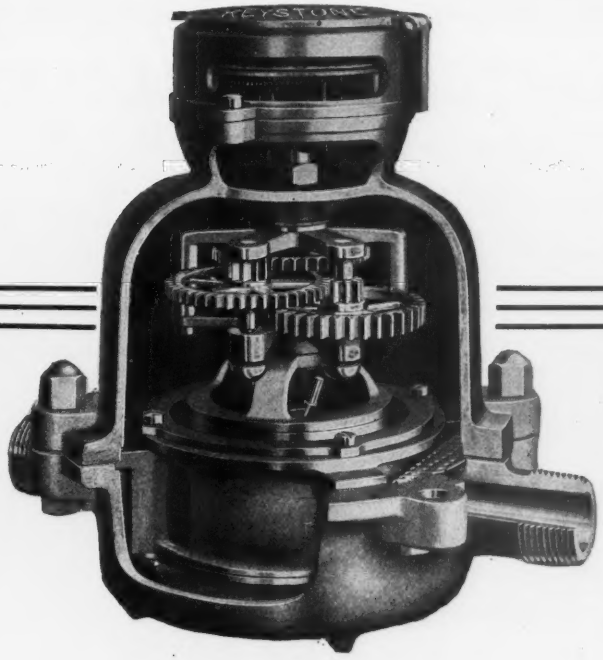

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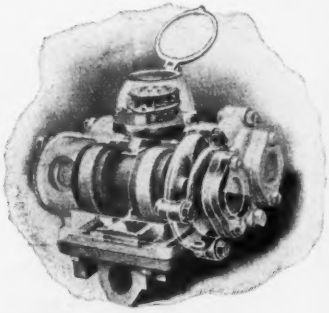

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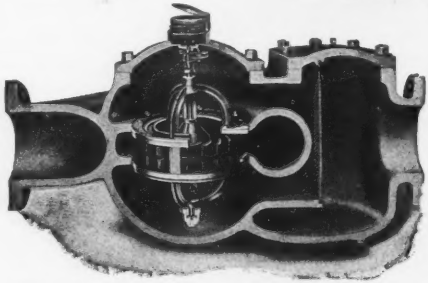

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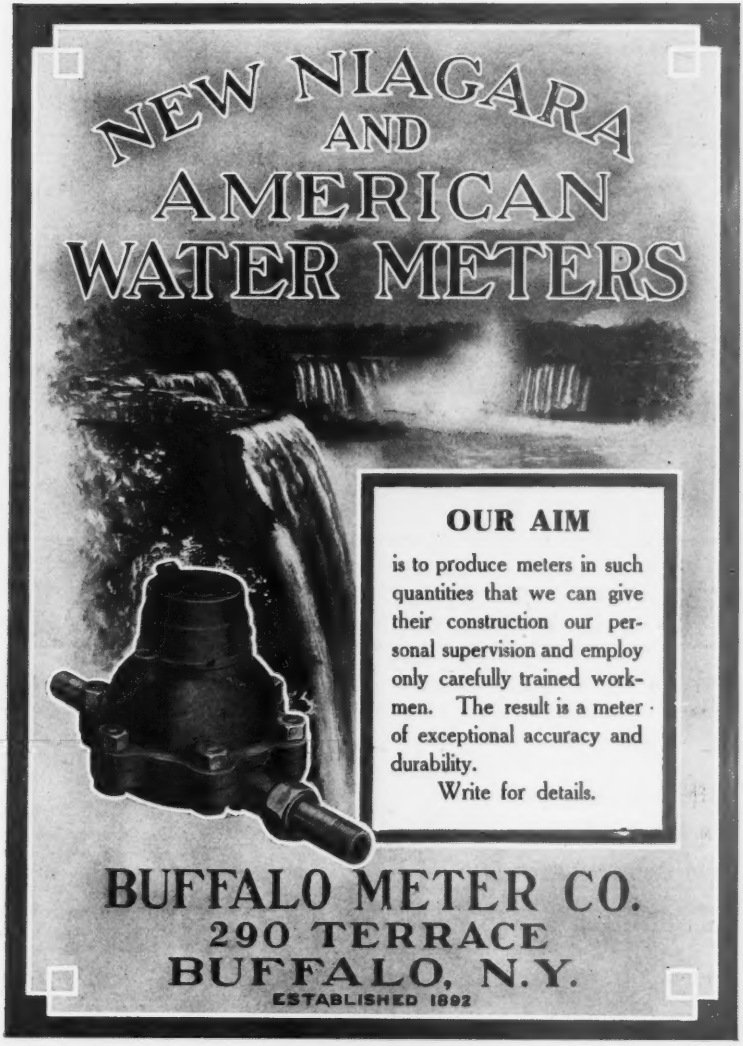
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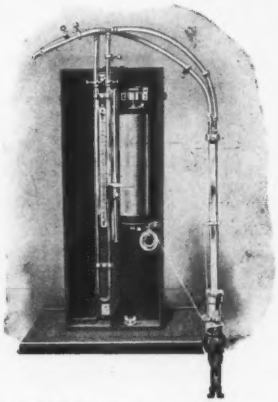

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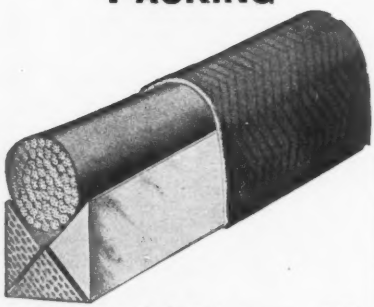

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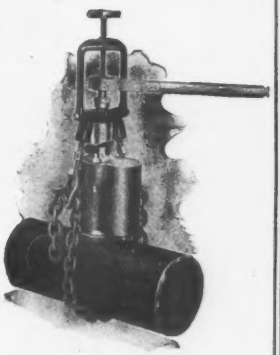

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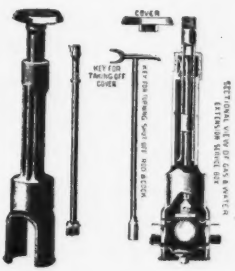

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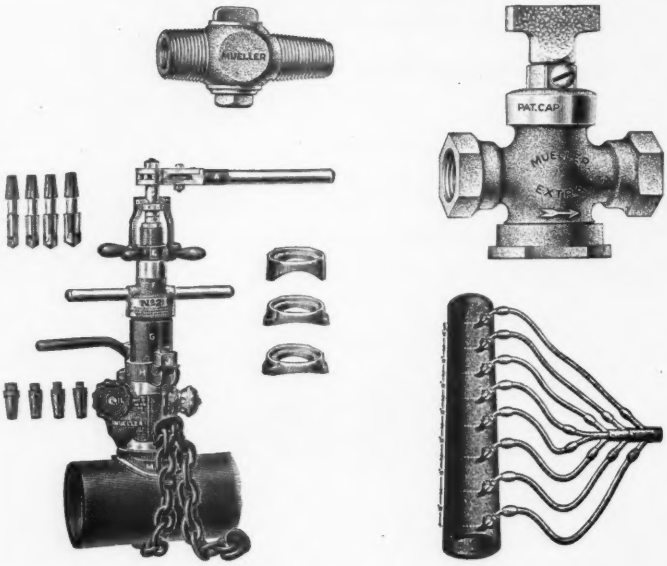

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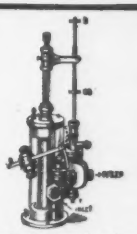

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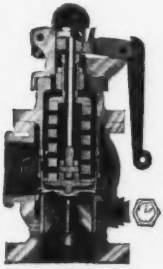

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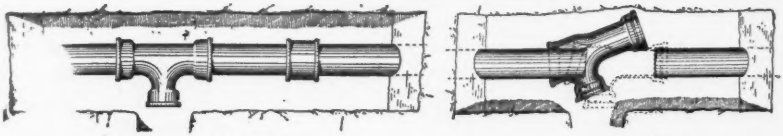

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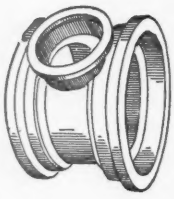

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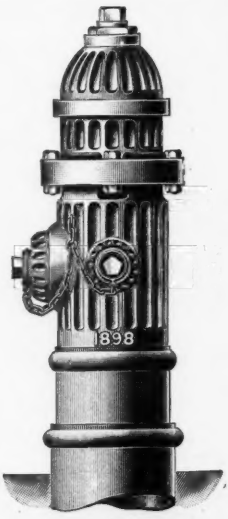

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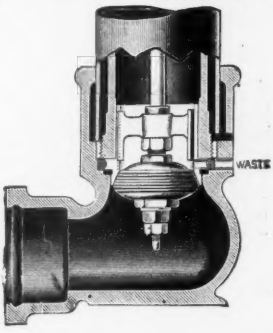

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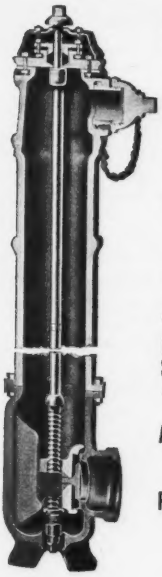

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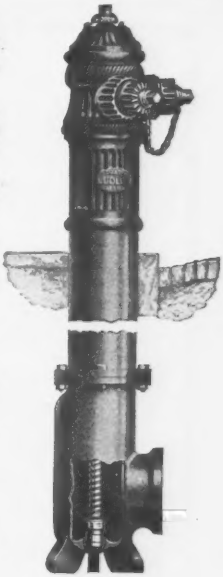

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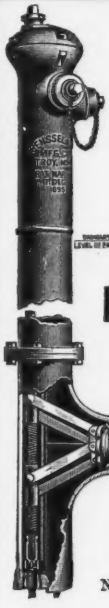

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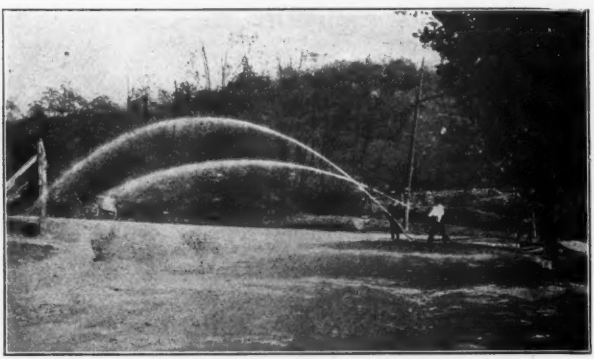

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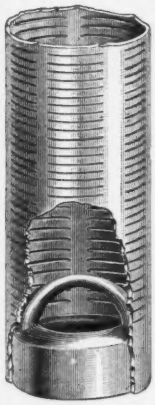

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